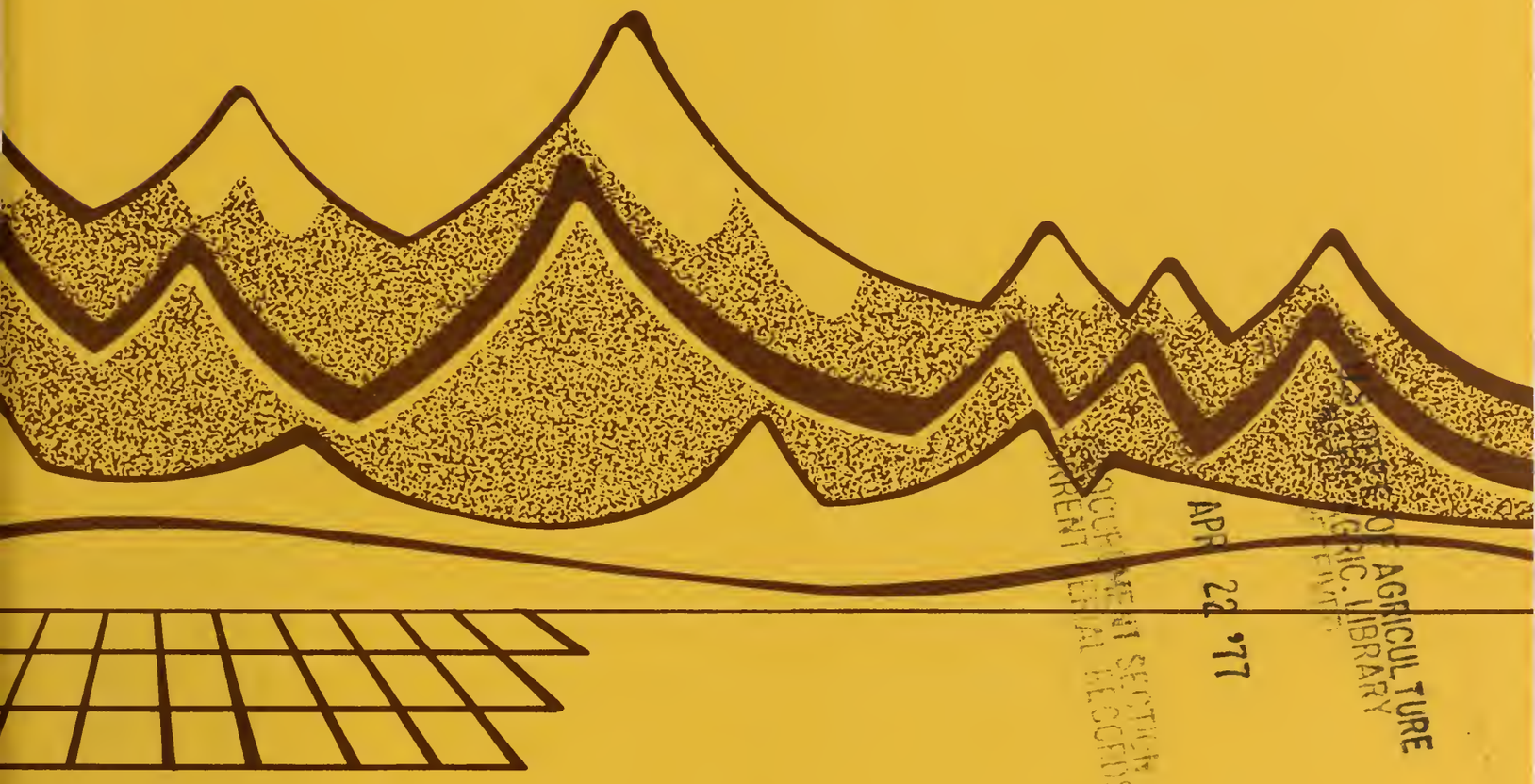
Rocky Mountain Forest and Range Experiment Station: A list of published research

April 1, 1972 through March 31, 1976



USDA Forest Service
General Technical Report RM-31

November 1976

Rocky Mountain Forest and Range Experiment Station
Forest Service
U. S. Department of Agriculture
Fort Collins, Colorado 80521

Foreword

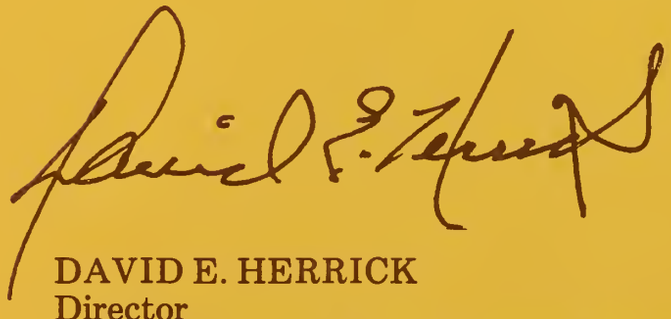
For years, we prepared an annual report entitled *Forestry Research Highlights.* The last issue covered 1971.

In 1973, we joined with the other Forest Service Experiment Stations in the West — Intermountain, Pacific Northwest, and Pacific Southwest — to print a publication entitled *Forestry Research, What's New in the West.* It is produced two to four times a year and carries feature stories about ongoing research plus short articles on recent publications of import to resource managers. The types of information previously included in our annual report are now covered by this publication which transfers research highlights to resource managers and other interested persons throughout the West. If you are not receiving *Forestry Research, What's New in the West* and would like to, send us a note and we will place you on the mailing list.

We have not printed a consolidated list of Station publications, by subject categories, since our last annual report (though we continue to send our quarterly publications list to thousands of interested persons and institutions). Therefore, we thought it appropriate to assemble this annotated list for the succeeding research years — April 1, 1972 through March 31, 1976. We hope it will help you identify publications of the period that might be useful to you.

In addition, we have just completed the History of Forest Service Research in the Central and Southern Rocky Mountain Regions 1908-1975 (General Technical Report RM-27). It contains a summary of major developments throughout the Station's history including much of the 4 year period since our last annual report. If you would like a copy of the history, or any of the publications listed here that are in print, write to:

Publications Distribution
Rocky Mountain Forest and Range Experiment Station
240 West Prospect
Fort Collins, Colorado 80521



DAVID E. HERRICK
Director
Rocky Mountain Forest and Range Experiment Station
November 1976

USDA Forest Service
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Rocky Mountain Forest and Range Experiment Station: A List of Published Research, April 1, 1972 through March 31, 1976

The Rocky Mountain Forest and Range Experiment Station maintains central headquarters at Fort Collins, in cooperation with Colorado State University.

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Note: This list is an initial effort to assign these research publications to subject categories. No attempt is made to cross reference or provide a comprehensive indexing system. Many publications could be appropriately listed under several subjects. In this list, however, they appear only once in what seems to be the most pertinent category.

FIRE AND ATMOSPHERIC SCIENCES

*Private, State or Federal cooperator

Fuels, Fire Danger

DEEMING, JOHN E., JAMES W. LANCASTER, MICHAEL A. FOSBERG, R. WILLIAM FURMAN, AND MARK J. SCHROEDER.*

1972.

National fire-danger rating system.

USDA For. Serv. Res. Pap. RM-84, 165 p.

The NFDR System produces three indexes -- occurrence, burning, and fire load -- that measure relative fire potentials. These indexes are derived from the fire behavior components -- spread, energy release, and ignition -- plus a consideration of risk. Contains instructions and tables to manually compute the indexes and components for nine broad fuel models.

DEEMING, JOHN E., JAMES W. LANCASTER, MICHAEL A. FOSBERG, R. WILLIAM FURMAN, AND MARK J. SCHROEDER.*

1974.

National Fire-Danger Rating System.

USDA For. Serv. Res. Pap. RM-84, 53 p. (Rev.)

The NFDR System produces three indexes--occurrence, burning, and fire load--that measure relative fire potentials. These indexes are derived from the fire behavior components--spread, energy release, and ignition--plus risk. This revision provides the information necessary to understand and apply the system, but contains computational tables for only one of nine fuel models.

DEEMING, JOHN E.

1975.

Calculating fire-danger ratings: Computer vs. tables.

Fire Manage. 36(1):6-7, 9.

Fire-danger rating values derived using NFDRS tables often differ somewhat from computer-derived values. Operational significance of the differences is small, however. The computer is more accurate and consistent, but the manual method is adequate.

DEEMING, JOHN E., AND JAMES K. BROWN.*

1975.

Fuel models in the National Fire-Danger Rating System.

J. For. 73:347-350.

Fuel models were developed to provide data for the Spread and Energy Release Components of the NFDR System. The models quantitatively describe physical and chemical properties of fuel elements and fuel beds that govern flammability. Nine models representing broad vegetative types have been developed.

FOSBERG, MICHAEL A.

1972.

Theory of precipitation effects on dead cylindrical fuels.

For. Sci. 18:98-108.

Numerical and analytical solutions of the Fickian diffusion equation were used to determine the effects of precipitation on dead cylindrical forest fuels. The analytical solution provided a physical framework. The numerical solutions were then used to refine the analytical solution through a similarity argument. The theoretical solutions predicted realistic rates of water exchange and the internal distribution of the water. The theory also (1) predicted that precipitation duration rather than amount or rate determined the amount of water uptake and (2) provided a function useful in practical applications.

FOSBERG, MICHAEL A.

1973.

Empirical refinement of the theoretical moisture diffusivity.

Wood Sci. 6:190.

Responds to comments by Bramhall and Warren (4(4):245-247) on a previous article by Fosberg et al.: Laboratory and theoretical comparison of desorption in ponderosa pine dowels, 3(2):94-99. Bramhall's reply follows.

FOSBERG, MICHAEL A.

1973.

Prediction of prepyrolysis temperature rise in dead forest fuels.

Fire Technol. 9:182-188.

The heat transfer rate to forest fuels ahead of a flaming fire front is highly variable over the interval of time required to preheat the fuels. An analytical function was derived which permitted inclusion of this varying transfer rate in the calculation of temperature rise for forest fuels.

FOSBERG, M. A.

1975.

Prediction of water vapor flux in conifer forest litter and duff.

Bull. Am. Meteorol. Soc. 56:112. (Abstr.)

This theoretical model of heat and vapor transport in forest soils includes particle sorption processes as well as porous media flow. It is primarily for predicting forest floor moisture for wildfire danger and fire behavior and effects.

FOSBERG, MICHAEL A.

1975.

Heat and water vapor flux in conifer forest litter and duff: A theoretical model.

USDA For. Serv. Res. Pap. RM-152, 23 p.

The model was developed from numerical and analytical solutions of the diffusion forms of the mass continuity equation and the first law of thermodynamics. Analytical solutions provided a functional framework to evaluate nonlinear interactions obtained in the numerical solutions.

FOSBERG, MICHAEL A.

1975.

Prediction of water vapor flux in conifer litter and duff.

Conf. Agric. For. Meteorol. [Tucson, Ariz., Apr. 1975] Proc. 12:21-22. Am. Meteorol. Soc., Boston, Mass.

The model more closely describes the physical processes in sorbing porous media than models based on hydraulic conductivity or diffusivity. Also, it is very responsive to vapor exchange processes. Qualitative predictions by the model compare well with observations.

FURMAN, R. WM.

1972.

A stochastic model for deriving the moisture content of heavy fuels.

Am. Meteorol. Soc. Bull. 53:1032. (Abstr.)

The model estimates moisture content of 3/4- to 3-inch fuels in terms of persistence and observed 1/2-inch stick moisture. The model depends on a Monte Carlo simulation of a segmented exponential distribution. Correlation between predicted and measured fuel moisture is 0.94.

FURMAN, R. WILLIAM, AND ROBERT S. HELFMAN.*
1973.
Computer time-sharing used with NFDRS.
Fire Manage. 34(2):14-16.
A computer communications system is described that can collect meteorological information, compute fire-danger ratings, and display this information upon request.

FURMAN, R. WILLIAM.
1975.
Estimating moisture content of heavy forest fuels.
For. Sci. 21(2):135-139.
A linear model estimates moisture content of the 100-hour timelag fuels. Variables include yesterday's computed value for 100-hour timelag fuel moisture, today's observed 10-hour timelag fuel moisture, and a binary variable which is set if it has rained in the past 24 hours.

HELFMAN, ROBERT S.,* JOHN E. DEEMING, ROBERT J. STRAUB, AND R. WILLIAM FURMAN.
1975.
User's guide to AFFIRMS: Time-share computerized processing for fire danger rating.
USDA For. Serv. Gen. Tech. Rep. RM-15, n.p. [107 p.]
Procedures for processing fire-danger data utilizing a time-share computer via a remote terminal are presented in language for persons without computer background. Input includes fuels and weather information; output includes messages sent from other users, displays of observed and forecasted weather, and fire danger indexes.

MCCAMMON, BRUCE P., AND DAVID A. RAINEY.
1973.
Fire-danger index generation.
Hewlett-Packard Keyboard 5(1):17-18.
A modification of a FORTRAN IV program, which calculates real time fire danger indices, was developed to be used as a research tool and to provide a quick, accurate method of calculating values from the field.

MC CAMMON, BRUCE P.
1974.
Snowpack influences on dead fuel moisture.
Bull. Am. Meteorol. Soc. 55:71. (Abstr.)
Fuels approached fiber saturation during the snowpack accumulation period. The short melt period provided very little liquid water for further moisture uptake. Large, dead, forest fuels emerge from a snowpack at approximately 32 percent moisture content by weight.

STRAUB, ROBERT J.
1975.
Cost reduction for AFFIRMS display options.
Fire Manage. 36(1):8-9.
Changing the display format is the least painful way to reduce the cost of AFFIRMS. Some ways to cut costs: Use short displays, carefully suppress headings, minimize use of SIG and Forest displays, consolidate displays to minimize display commands.

Hazard Reduction, Controlled Use of Fire

DEEMING, JOHN E., AND DALE D. WADE.*
1974.
A clarification...wildfire suppression terminology.
Fire Manage. 35(3):10-11.
Suppression firing is the general term describing the intentional application of fire to speed up or strengthen wildfire control action. It includes the tactical terms counter firing, burning out, and mopup burning. Firing techniques used include head fire, flank fire, backfire, etc.

Effects of Fire, Fire Ecology

CABLE, DWIGHT R.
1972.
Fire effects in southwestern semidesert grass-shrub communities.
Tall Timbers Fire Ecol. Conf. [Lubbock, Tex., June 1972] Proc. 12:109-127.
Planned burning can limit the encroachment of shrubby species into grassland, and prevent them from reaching seed-bearing size. It will seldom increase perennial grass production, may reduce production temporarily, and will probably change relative abundance of perennial grass species.

KRUSE, WILLIAM H.
1972.
Effects of wildfire on elk and deer use of a ponderosa pine forest.
USDA For. Serv. Res. Note RM-226, 4 p.
After a wildfire, elk use shifted from an old seeded clearcut to a newly seeded burn for the first 2 years. The third year showed an equalizing trend of elk use between the two habitat conditions. The trend of decreasing deer use on thinned areas continued, but use increased substantially on the wildfire area.

PEARSON, H. A., J. R. DAVIS, AND G. H. SCHUBERT.
1972.
Effects of wildfire on timber and forage production in Arizona.
J. Range Manage. 25:250-253.
A severe May wildfire decimated an unthinned ponderosa pine stand; an adjacent thinned stand was relatively undamaged. Radial growth increased on burned trees with less than 60 percent crown kill. Burning initially stimulated growth and nutrient value of herbaceous vegetation in both stands. Seeded areas produced most herbage after 2 years.

SCHOLL, DAVID G.
1975.
Soil wettability and fire in Arizona chaparral.
Soil Sci. Soc. Am. Proc. 39:356-361.
Relatively cool fires caused water repellence at the surface. Hot fires caused repellence at greater depth, but the surface layer was rendered completely wettable. Organic matter decreased at progressively higher temperatures. Organic material causing repellence is almost completely lost above 270 C.

Fire Management, Fire Behavior

DEEMING, JOHN E., AND R. WILLIAM FURMAN.
1974.
Automation of the National Fire Danger Rating System--impacts on fire management.
Bull. Am. Meteorol. Soc. 55:68. (Abstr.)
Experience with the interactive time-share computer system was very encouraging. Time required to process observations and forecasts was comparable to that needed to complete hand calculations. Overall, costs were considered reasonable.

LINDENMUTH, A. W., JR., AND JAMES R. DAVIS.
1973.
Predicting fire spread in Arizona's oak chaparral.
USDA For. Serv. Res. Pap. RM-101, 11 p.
Existing fire models did not adequately predict rate-of-spread (ROS). A statistical model developed using essentially the same input variables but weighted differently accounted for 81 percent of the variation in ROS. A coefficient that accounts for effects of fuel chemistry is applied to the model.

LANCASTER, JAMES W.
1972.
Fire danger rating for loggers' use.
West. For. Fire Comm. [Seattle, Wash., Dec. 1972] Annu. Meet. 1972:15-19. West. For. Conserv. Assoc., Portland, Oreg.
The National Fire Danger Rating System predicts fire occurrence, behavior, and containment by means of related components and indexes. It is now used primarily for presuppression planning, but should have wide application in regulating forest use.

LANCASTER, JAMES W.
1973.
Practical applications of the National Fire-Danger Rating System.
Eighth Annu. Meet. Middle Atlantic Interstate For. Fire Protection Compact. [Cape Henlopen State Park, Lewes, Delaware, Sept. 18-20] Proc., p. 43-51.
Describes the fire behavior components and fire management indexes of the NFDR System, and how managers can use them in presuppression planning.

LANCASTER, JAMES W.
1974.
Fire management applications of the National Fire Danger Rating System.
Bull. Am. Meteorol. Soc, 55:70. (Abstr.)
Increased capabilities of the National Fire Danger Rating System have given fire managers new tools for evaluating various facets of fire management problems. Examples of suggested approaches for use of NFDR numbers in prevention, presuppression planning, and in initial attack efforts are presented.

LANCASTER, JAMES W.
1974.
Fire management applications of the National Fire Danger Rating system.
SAF-AMS Joint Conf. on Fire and For. Meteorol. [Lake Tahoe, Calif., Apr. 1974] Pap., 27 p.
Increased capabilities of the NFDR System have given fire managers new tools for evaluating various facets of fire management problems. Suggested approaches for use of NFDRS numbers in prevention, presuppression planning, and in initial attack efforts are presented. Specific examples are shown.

Weather, Meteorology, Climatology

BERGEN, JAMES D.
1972.
Windspeed distribution in and near an isolated clearing in a pine stand.
Am. Meteorol. Soc. Bull. 53:1028. (Abstr.)
Ratios of measured speeds to estimated friction velocity calculated from speeds on a reference tower above the canopy were almost constant over a wide range of speeds and stabilities. The clearing is filled with level or ascending flow, with subsidence in the lee.

BERGEN, JAMES D.
1974.
Variation of windspeed with canopy cover within a lodgepole pine stand.
USDA For. Serv. Res. Note RM-252, 4 p.
The linear correlation computed for 22 points in a lodgepole pine canopy suggests independence between the point-to-point variations in speed at any level and variations of total canopy cover.

BERGEN, JAMES D.
1974.
Variations of air temperature and canopy closure in a lodgepole pine stand.
USDA For. Serv. Res. Note RM-253, 3 p.
Air temperatures were scaled by temperature gradient over the canopy, and point-to-point variation of this scaled temperature from deviations of canopy view factor. Results indicate independence at all the levels for which temperature was measured.

BERGEN, JAMES D.
1974.
The independence of the point-to-point variations in windspeed and temperature in a lodgepole pine stand.
USDA For. Serv. Res. Note RM-258, 2 p.
The correlation between local variations in air temperature and windspeed at particular levels in a pine stand are examined for evidence of persistent momentum transport by thermal convection. The results argue against such an effect.

BERGEN, JAMES D.
1974.
Airflow velocities and separation patterns in a forest clearing as indicated by smoke drift measurements.
Bull. Am. Meteorol. Soc. 55:74. (Abstr.)
Cinematic observations were made of the behavior of multiple smoke plumes in an isolated clearing cut in an even-aged stand of lodgepole pine. The results indicate a continuous alternation between separated and unseparated flow. The effect appears relevant to the behavior of forest roads in regard to pollutant emission and fire spread.

BERGEN, JAMES D.
1974.
Vertical air temperature profiles in a pine stand: Spatial variation and scaling problems.
For. Sci. 20:64-73.
Results indicate strong horizontal temperature variation in the crown space in an even-aged lodgepole pine stand. Horizontal movement of sensible heat could be comparable to that in the vertical. A composite temperature profile indicates maximum temperatures at the level of maximum foliage and at the stand floor.

BERGEN, JAMES D.
1974.
The relation between density, grain size and solar albedo for natural snow cover.
EOS Trans. Am. Geophys. Union 56:1117. (Abstr.)
A simple model is proposed for the solar albedo of natural snow cover. The model is based on the Carmen-Kozney relation between sieve grain size, snow density, and air permeability developed by Bender.

BERGEN, J. D.
1975.
The windflow in an isolated forest clearing.
Bull. Am. Meteorol. Soc. 56:116. (Abstr.)
Widening a narrow clearing in a lodgepole pine forest from one tree height in width to three increased scaled windspeeds at almost all points by factors approaching 200 percent.

BERGEN, JAMES D.
1975.
An approximate analysis of the momentum balance for the airflow in a pine stand.
p. 287-298. *In* Heat and mass transfer in the biosphere. Part 1. Transfer processes in the plant environment, edited by D.A. deVries and N.H. Afgan. 594 p. Scripta Book Co., Wash., D.C.
An approximate model of airflow in a pine canopy is used to estimate velocity profiles, volume drag coefficient, and effective viscosity from windspeed and foliage distribution measurements. Live branches are the characteristic drag element, and viscosity has an appreciable dispersive component.

BERGEN, J. D.

1975.

Air movement in a forest clearing as indicated by smoke drift.

Agric. Meteorol. 15:165-179.

Cinematic observations indicate a continuous alternation between separated and unseparated flow. The flow sequence includes a central vortex, which appears to dominate the distribution and direction of the maximum speed and surface shear stress in the clearing.

BERGEN, JAMES D.

1975.

A possible relation of albedo to the density and grain size of natural snow cover.

Water Resour. Res. 11(5):745-746.

A simple model is proposed for the solar albedo of natural snow cover, based on an approximation to the specific surface by a function of grain size and density derived from air permeability measurements. Agreement with limited observational material is good. The model suggests that, for grain sizes greater than 1.5 mm, density is the primary factor governing albedo.

CAMPBELL, RALPH E.

1972.

Prediction of air temperature at a remote site from official weather station records.

USDA For. Serv. Res. Note RM-223, 4 p.

Air temperatures at the San Luis experimental watershed were predicted from temperatures at Albuquerque, New Mexico on the basis of linear regressions between temperatures at the two locations calculated from a full year of continuous record at San Luis and official 3-hour records at Albuquerque. Predictions of daily mean temperatures at San Luis were within plus or minus 3.8 degrees F. Monthly mean temperatures for a given time of day were predicted within plus or minus 3.6 degrees to 5.5 degrees depending on time of day. Hourly temperatures were predicted within plus or minus 6.3 degrees to 7.8 degrees depending on time of day. All of these were within the 80 percent tolerance interval. within + or - 3.8 degrees F. Monthly mean temperatures for a given time of day were predicted within + or - 3.6 degrees to 5.5 degrees depending on time of day. Hourly temperatures were predicted within + or - 6.3 degrees to 7.8 degrees depending on time of day. All of these were within the 80 percent tolerance interval.

DEEMING, JOHN E., AND WILLIAM G. SULLIVAN.*

1974.

Automation of the National Fire Danger Rating System--impacts on the fire weather forecaster.

Bull. Am. Meteorol. Soc. 55:68. (Abstr.)

National Weather Forecast Offices in Arizona and California participated in the field trials of AFFIRMS (Automatic Forest Fire Information Management and Retrieval System). Communication of fire weather observations from the field to the forecaster and of fire weather forecasts from the forecaster to the users was greatly simplified.

FOSBERG, MICHAEL A., ALBERT RANGO,* AND WILLIAM E. MARLATT.*

1972.

Wind computations from the temperature field in an urban area.

Conf. Urban Environ. 2d Conf. Biometeorol. [Phila., Pa., Oct.-Nov. 1972] Proc., p. 5-7. Am. Meteorol. Soc., Boston, Mass.

A simple computation is proposed through which the wind field may be estimated from the observed temperature field. Integration of the circulation theorems by use of mean value theorems gives an expression for the vorticity. The stream function may then be determined from the vorticity through the choice of appropriate boundary conditions.

FOSBERG, MICHAEL A., AND R. WILLIAM FURMAN.

1973.

Fire climates in the Southwest.

Agric. Meteorol. 12:27-34.

Temperature and humidity were used to define mean equilibrium moisture content during season of high fire danger. Phenological stages of lesser herbaceous vegetation were taken as integrators of available moisture, and were used to evaluate moisture content of the fine fuel complex, which influences fire behavior.

FOSBERG, MICHAEL A., AND WILLIAM E. MARLATT.*

1974.

Calculation of airflow over complex terrain: I. Theory and model characteristics.

Bull. Am. Meteorol. Soc. 55:74. (Abstr.)

A mesoscale numerical model of boundary layer flow has been developed for use in complex terrain. The local flow characteristics are calculated from the thermodynamic structure by mean-value integration of the body forces. These local flow characteristics are superimposed on a background flow to obtain the total wind field.

FOSBERG, MICHAEL A., W. E. MARLATT,* AND LAWRENCE KRUPNAK.*

1975.

Estimation of airflow over complex terrain.

Bull. Am. Meteorol. Soc. 56:190. (Abstr.)

A one-layer model of boundary-layer flow was developed through use of impulse accelerations of thermal and frictional forces to modify the terrain-induced potential flow field. This model uses only data routinely collected in mountainous terrain.

FOSBERG, MICHAEL A., WILLIAM E. MARLATT,* AND LAWRENCE KRUPNAK.*

1976.

Estimating airflow patterns over complex terrain.

USDA For. Serv. Res. Pap. RM-162, 16 p.

A diagnostic model of the vector flow field requires much less data than traditional approaches, and therefore can be used as an estimator of wind patterns in areas where dense observational networks are not feasible. Intended primary uses are in providing wind fields for predicting fire Intended primary uses are in providing wind fields for predicting fire behavior and evaluating pollution transport patterns.

FOSBERG, MICHAEL A.

1976.

New technology for determining atmospheric influences on smoke concentrations.

p. 148-159. *In* Air quality and smoke from urban and forest fires. Int. Symp. [Fort Collins, Colo., Oct. 1973] Proc. Natl. Acad. Sci., Wash., D.C. 381 p.

A numerical diagnostic model of atmospheric boundary layer flow, developed for use in mountainous wildland areas, is based on a mean value integration of the body forces in the vorticity and divergence forms of the Navier-Stokes equations. The model is readily adaptable to many environmental problems; data may be from direct observation or remote sensing of the thermal structure of the atmosphere.

FURMAN, R. WILLIAM, AND ROBERT S. HELFMAN.*

1973.

A computer program for processing historic fire weather data for the National Fire-Danger Rating System.

USDA For. Serv. Res. Note RM-234, 12 p.

FIRDAT is a FORTRAN IV program to compute the daily components and indexes of the National Fire-Danger Rating System. FIRDAT will also compute and print the absolute, relative, and cumulative frequencies of occurrence, and print a cumulative frequency distribution for each of the components and indexes.

FURMAN, R. WILLIAM.

1975.

An aid to streamlining fire-weather station networks.

USDA For. Serv. Gen. Tech. Rep. RM-17, 4 p.

A method is proposed for determining degree of duplication in monitoring fire climate, based on an analysis of similarity of sequences of six fire climate elements over the fire season.

FURMAN, R. WILLIAM, AND GLEN E. BRINK.
1975.
The national fire weather data library: What it is and how to use it.
USDA For. Serv. Gen. Tech. Rep. RM-19, 8 p.
The National Fire Weather Data Library is a computerized collection of daily weather conditions from fire weather stations across the Nation. Current data are accumulated on collection tapes, then merged onto library tapes annually. Example outputs are given for the UNIVAC 1108 computer at USDA's Fort Collins Computer Center.

GARY, HOWARD L.
1975.
Canopy weight distribution affects windspeed and temperature in a lodgepole pine forest.
For. Sci. 20:369-371.
Weight distribution of needles plus branches approximated a normally distributed population for 10 randomly selected trees in an 80-year-old stand in southern Wyoming. Windspeeds were minimum and midday air temperatures maximum in the midcanopy region where needles and branch weight were concentrated.

MARLATT, WILLIAM E.,* AND MICHAEL A. FOSBERG.
1974.
Calculation of airflow over complex terrain: II. Application of the WINDS model to problems of environmental impacts in mountainous regions.
Bull. Am. Meteorol. Soc. 55:74. (Abstr.)
The numerical model described in the previous paper has been used operationally to solve a number of practical problems associated with possible environmental impacts in mountainous regions. Applications of the WINDS model in studies of power plant siting, strip mining, prescribed burning, and ski development will be demonstrated.

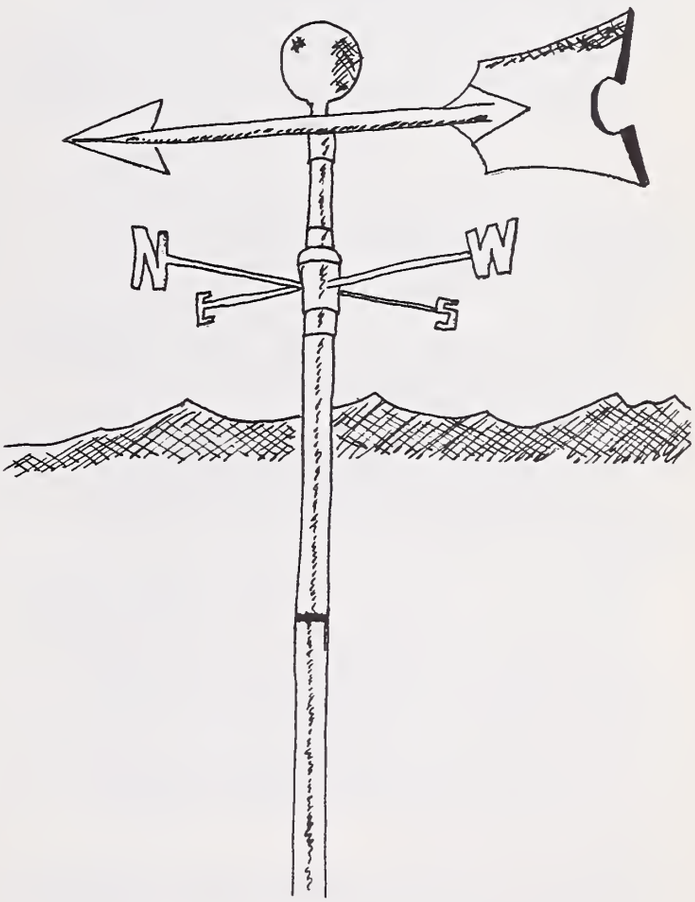
MARLATT, W. E.,* AND M. J. (A.) FOSBERG.
1976.
WINDS--A model for calculating the boundary layer flow and air pollution potential in complex terrain.
Bull. Am. Meterol. Soc. 57(2):279. (Abstr.)
The model is based on terrain, thermally and frictionally induced flows superimposed on a background potential flow, and incorporates both divergence and vorticity. It has been used successfully for studies of air pollution potential and design of air quality maintenance areas.

THILENIUS, JOHN, AND DENNIS KNIGHT.*
1975.
Snow duration and growing season microclimate in alpine tundra and subalpine meadows.
p. 23-37. *In* The Medicine Bow ecology project, final report, February 28, 1975. D. H. Knight, coord., Univ. Wyo., Laramie, for Div. Atmos. Water Resour. Manage., Bur. Reclam., U.S. Dep. Int., Denver, Colo.
Summarizes the microclimatic regimes of two alpine tundra and four subalpine meadow sites over a 2-year period, including air and soil temperatures, solar radiation, rainfall and snow accumulation, soil moisture, windspeed, vapor pressure deficit, and relative humidity. (Entire report available from NTIS, 397 p., $3.)

Air Pollution

FOX, DOUGLAS G.
1975.
Impact of concentrated recreational development on air quality.
p. 259-273. *In* Man, leisure, and wildlands: A complex interaction. [Proc. First Eisenhower Consortium Res. Symp., Sept. 14-19, 1975, Vail, Colo.] Eisenhower Consortium Bull. 1, 286 p.
Air quality considerations and modeling techniques to evaluate environmental impacts of mountain and wildland developments are presented. A suggested procedure provides for quantification of air pollutants emitted from concentrated recreation facilities, and identification of their effects. Suggested regional air quality maintenance plans should incorporate continual monitoring.

Blowing Snow: See Snow Fences, Blowing Snow under WATERSHED MANAGEMENT



FOREST INSECTS AND DISEASES (Including Controls)

*Private, State or Federal cooperator

Seedling Diseases

PETERSON, GLENN W.
1974.
Disease problems in the production of containerized forest tree seedlings in North America.
p. 170-172. *In* North Am. Containerized For. Tree Seedling Symp. [Denver, Colo., Aug. 1974] Proc. Great Plains Agric. Counc. Publ. 68, 458 p.
Severe losses of Douglas-fir and other conifers by grey mold and damping-off can be expected in greenhouses if humidity remains high in vicinity of seedlings. Losses can be reduced by increased movement of air near seedlings, by fungicides, and by sanitation.

PETERSON, GLENN W., AND RICHARD S. SMITH, JR. (TECH. COORD.)
1975.
Forest nursery diseases in the United States.
U.S. Dep. Agric., Agric. Handb. 470, 125 p.
Discusses hosts, symptoms, damage, life cycles, distribution of pathogens, and methods for control for 31 diseases of seedlings in forest nurseries--9, root; 8, stem and branch; 14, foliage. Includes a short discussion on storage molds, plus selected references, glossary, disease index, and host index.

Foliage and Twig Diseases

PETERSON, GLENN W.
1972.
Chemical control of Phomopsis blight of junipers: A search for new methods.
Tree Plant. Notes 23(3):3-4.
Only phenyl mercury fungicides effectively control phomopsis blight, but environmental constraints severely restrict their use. Other fungicides proved ineffective against phomopsis in the literature are listed to prevent duplication of research.

PETERSON, GLENN W.
1973.
Biology and control of some conifer diseases encountered in landscapes in the midwestern United States.
Woody Ornamental Dis. Workshop [Columbia, Mo., Jan., 1973] Proc. 1:111-128.
Discusses Dothistroma needle blight, brown spot needle blight, Lophodermium needlecast, and Diplodia tip blight of pines, and Phomopsis blight and Cercospora blight of junipers.

PETERSON, GLENN W.
1973.
Infection of *Juniperus virginiana* and *J. scopulorum* by *Phomopsis juniperovora*.
Phytopathology 63:246-251.
Nonwounded new foliage was highly susceptible to infection; lesions did not develop on old foliage. Germination of spores, germ-tube development, and growth in culture were optimum near 24 C. Disease development was enhanced by high post-incubation temperatures (32 C.).

PETERSON, GLENN W.
1973.
Infection of Austrian and ponderosa pines by *Dothistroma pini* in eastern Nebraska.
Phytopathology 63:1060-1063.
Conidia were trapped by May 15. They were disseminated only during periods with rain. Current-year needles were not infected before July 13, older needles as early as May 20. Symptoms appear 11-16 weeks after infection. June-September rainfall is a good indicator of amount of infection to be expected.

PETERSON, GLENN W., AND DAVID A. GRAHAM.*
1974.
Dothistroma needle blight of pines.
U.S. Dep. Agric. For. Pest Leafl. 143, 5 p.
This fungus can be severly damaging, especially in Christmas tree plantations. Twenty North American pines and hybrids are known hosts. Copper fungicides effectively prevent infection, but timing depends on variable susceptibility of current and previous-years' needles.

PETERSON, GLENN W.
1974.
Infection of shoots and cones of Austrian pine by *Diplodia pinea*.
Proc. Am. Phytopathol. Soc. [Vancouver, B.C., Aug. 1974] 1:110. (Abstr.)
D. pinea severely damages Austrian, ponderosa, and Scots pines over 30 years old in Great Plains plantings. Two applications of Bordeaux mixture between April 24 and May 8 reduced shoot infection 87 percent. Applications after May 14 were ineffective. These applications to protect shoots did not protect susceptible second-year cones, however.

PETERSON, GLENN W.
1975.
Dothistroma needle blight: A problem in production of landscape pines.
Am. Nurseryman 141(12):11, 94-96.
The most likely source of this fungus is on infected seedlings, such as lining stock, brought into the nursery. Bordeaux mixture applied in early May will protect old needles; a mid-June application is necessary to protect new needles. Only one application, in mid-June, will give satisfactory protection in most years.

PETERSON, GLENN W., AND C. S. HODGES, JR.*
1975.
Phomopsis blight of junipers.
U.S. Dep. Agric., For. Pest Leafl. 154, 6 p.
Phomopsis juniperovora blight is common in nurseries from the Great Plains to the Atlantic, primarily on eastern redcedar and Rocky Mountain juniper. Young, unwounded needles are susceptible throughout the growing season. Since mercury fungicides can no longer be used, Benomyl is the only fungicide registered for controlling phomopsis.

STALEY, J. M., AND H. H. BYNUM.*
1972.
A new *Lophodermella* on *Pinus ponderosa* and *P. attenuata*.
Mycologia 64:722-726.
Lophodermella morbida, an aggressive pathogen of pine foliage, was collected from northern California, Oregon, and Washington locations west of the Cascade crest. Evidence suggests the fungus is endemic and limited to environments having moist, moderate climates.

STALEY, J. M.
1975.
The taxonomy of Lophodermia on pines, with special reference to problems in North American Christmas tree plantations.

p. 79-85. *In* Lophodermium in pines. Proc. 5th Eur. Colloq. For. Pathol. [Schmalenbeck, Apr. 1975.]

A species concept for *Lophodermium pinastri* based on the type specimen cited by Chevallier is described as essential to resolution of taxonomic complexities among Lophodermia. Symptomological, phenological, morphological, and cultural characteristics can be used to separate the various taxa.

STALEY, J. M.

1975.

The development on, and penetration into *Pinus sylvestris* foliage, of a pathogenic Lophodermium.

p. 43-45. *In* Lophodermium in pines. Proc. 5th Eur. Colloq. For. Pathol. [Schmalenbeck, Apr. 1975.]

A *Lophodermium* species distinct from *L. pinastri* is capable of attacking current year and older foliage of *Pinus sylvestris*. Ascospores appear to lodge at irregularities on wet needle surfaces. Penetration hyphae enter directly through the cuticle and epidermis. The pathogen is readily controlled by maneb, benlate, or fundalin.

UECKER, F. A.,* AND J. M. STALEY.

1973.

Development of the ascocarp and cytology of *Lophodermella morbida*.

Mycologia 65:1015-1027.

Events of a 1-year life cycle are described. Cytology, and development of asci from an ascogenous hyphal system with crozier formation, are typical of many ascomycetes. The haploid number of chromasomes is 8 or 9.

WHEELER, MARGARET M.,* DESMOND M. S. WHEELER,* AND GLENN W. PETERSON.

1975.

Anthraquinone pigments from the phytopathogen *Phomopsis juniperovora* Hahn.

Phytochemistry 14:288-289.

The yellow-orange coloration that forms on agar in diagnostic tests for *P. juniperovora* is primarily due to 7-methoxy-2-methyl-1,2,3,4,5-pentahydroxy-1,2,3,4-tetrahydroanthraquinone.

Root and Stem Diseases

HINDS, T. E.

1972.

***Ceratocystis* canker of aspen.**

Phytopathology 62:213-220.

Several species of *Ceratocystis* are associated with a trunk canker on quaking aspen. *C. fimbriata* is a causal agent. The primary point of canker initiation is at fresh bark wounds.

HINDS, T. E.

1972.

Insect transmission of *Ceratocystis* species associated with aspen cankers.

Phytopathology 62:221-225. (Reprinted in: J.W. Brewer and M.D. Harrison, eds. 1973. Readings in insect-plant disease relationships. p. 267-278. MSS Inf. Corp., N.Y.)

Nitidulids are considered the principal vectors of *Ceratocystis* canker of aspen in Colorado. Two rove beetles and a root-eating beetle were also vectors of *C. fimbriata* and other *Ceratocystis* species.

HINDS, T. E., AND R. W. DAVIDSON.*

1972.

***Ceratocystis* species associated with the aspen ambrosia beetle.**

Mycologia 64:405-409.

A new species, *Ceratocystis retusi*, characterized by brown perithecia and long flexuous, ostiolar filaments, is described. This species and *C. brevicollis* were commonly found in the pupal cells of the aspen ambrosia beetle, *Typodendron retusum*, in Colorado.

HINDS, T. E., AND R. W. DAVIDSON.*

1975.

Two new species of *Ceratocystis*.

Mycologia 67(4):715-721.

Describes *Ceratocystis ponderosae*, from blue stain of ponderosa pine, and *C. fraxinopennsylvanica*, from brown stain in bark beetle galleries of green ash. *C. ponderosae* is morphologically similar to *C. pilifera* but differs in growth habit and staining ability. The ostiolar tip and imperfect state of *C. fraxinopennsylvanica* are characteristic.

HINDS, T. E., AND R. G. KREBILL.*

1975.

Wounds and canker diseases on western aspen.

U.S. Dep. Agric., For. Pest Leafl. 152, 9 p.

Trunk wounds to the fragile, living bark are the most common entrance points for canker disease fungi, the most serious cause of aspen mortality. No chemical control measures are known.

HINDS, T. E.

1976.

Aspen mortality in Rocky Mountain campgrounds.

USDA For. Serv. Res. Pap. RM-164, 20 p.

Aspens die from canker infections as a result of bark injuries inflicted by thoughtless campers. Dead trees usually are cut to reduce hazard. Aspen loss is related to campground age. A desirable unit can be degraded to a treeless site within 10 to 20 years.

LIGHTLE, PAUL C., AND JOHN H. THOMPSON.*

1973.

Atropellis canker of pines.

U.S. Dep. Agr. For. Pest Leafl. 138, 6 p.

Four Atropellis fungi collectively cause widespread canker disease of hard and soft pines throughout much of the U.S. and Canada. Control is based on silvicultural techniques to remove the source of inoculum, infected trees.

PETERSON, GLENN W.

1973.

Dispersal of aeciospores of *Peridermium harknessii* in central Nebraska.

Phytopathology 63:170-172.

Dispersal of western gall rust spores increased sharply in the morning as air temperature increased and relative humidity decreased. This periodicity was interrupted by rain. Aeciospore dissemination began in early May and was essentially complete by the end of June.

WYSONG, DAVID S.,* AND JERRY W. RIFFLE.

1975.

Cytospora canker of poplars and willows.

NebGuide G75-257, B-2, 4 p. Nebr. Univ., Lincoln.

Cytospora chrysosperma is one of several fungal pathogens that cause stem cankers on hardwood trees. The symptoms, disease cycle, and control of *Cytospora* canker on poplars and willows in Nebraska are described in this extension leaflet.

Mistletoes and Other Higher Parasitic Plants

ALEXANDER, MARTIN E., AND FRANK G. HAWKSWORTH.

1975.

Wildland fires and dwarf mistletoes: A literature review of ecology and prescribed burning.

USDA For. Serv. Gen. Tech. Rep. RM-14, 12 p.

Wildfires may either inhibit or encourage these parasites, depending primarily on the size and intensity of the burn. Fire

exclusion policies of the past half century may have increased dwarf mistletoe levels and fire potential. Prescribed burning may be a supplemental control tool in some forest types and stand conditions.

GREGOR, SUSAN,* DELBERT WIENS,* ROBERT E. STEVENS, AND FRANK G. HAWKSWORTH.

1974.

Pollination studies of *Arceuthobium americanum* in Utah and Colorado.

Southwest. Natur. 19:65-73.

A. americanum, a dwarf mistletoe parasitic on *Pinus contorta*, is thought to be insect pollinated since at least 25 insect species were observed on pistillate and staminate flowers. Diptera and Hymenoptera were most common.

HAWKSWORTH, FRANK G., AND DELBERT WIENS.*

1972.

Biology and classification of the dwarf mistletoes (*Arceuthobium*).

U. S. Dep. Agric., Agric. Handb. 401, 234 p.

Describes 32 recognized taxa: 28 species, 5 subspecies, and 2 *formae speciales*. Classification system is based on extensive field studies of New World species, examination of specimens in major herbaria of North America and Europe, and computer analyses of all taxonomic data.

HAWKSWORTH, F. G.

1972.

Biological control of the mistletoes.

p. 83-92. *In* Biological control of forest diseases. Int. Union For. Res. Organ. XV Congr. [Gainesville, Fla., Mar. 1971] Subj. Group 2, 105 p. Ottawa, Can. For. Serv.

Several insects and fungi are specific to dwarf mistletoes, but exert only a low degree of natural control. Most promising are certain canker fungi that inhabit host bark near mistletoes and limit mistletoe shoot production.

HAWKSWORTH, FRANK G.

1972.

Dwarf mistletoe control.

West. For. Pest Comm. [Seattle, Wash., Dec. 1972] Annu. Meet. 1972:51-52. West. For. Conserv. Assoc., Portland, Oreg.

Control efforts, as yet exclusively silvicultural, have been minimal because managers didn't know if the effort was economically justifiable. Yield simulation programs that include effects of mistletoe provide needed economic information. Some programs are now available for even-aged stands; programs for uneven-aged stands are being developed.

HAWKSWORTH, F. G.

1973.

Dwarf mistletoes (*Arceuthobium*) of coniferous forests of the world.

Eur. Weed Res. Counc. Symp. Parasit. Weeds [Malta, April 1973] Proc. 1973:231-235.

Briefly discusses the biology, means of dispersal, ecology, and methods of cultural and biological control of the dwarf mistletoes.

HAWKSWORTH, F. G.

1973.

On a new power source.

J. Irreproducible Results 20(1):20.

Describes the vast potential energy produced by exploding dwarf mistletoe fruits in coniferous forests throughout the West. Advocates harvesting this new power source to help alleviate the nation's energy crisis.

HAWKSWORTH, FRANK G., AND ED F. WICKER.*

1973.

***Nectria flammea* associated with scale insects on dwarf mistletoe in Honduras.**

Turrialba 23:365-367.

Describes the imperfect stage of the fungus on two scale insects, *Hemiberlesia rapax* and *Aspidiotus nerii*, which are parasitic on the rare dwarf mistletoe, *Arceuthobium hondurense*.

HAWKSWORTH, FRANK G.

1974.

Mistletoes on introduced trees of the world.

U.S. Dep. Agric., Agric. Handb. 469, 49 p.

This worldwide inventory includes only introduced host situations, where a tree is grown outside its natural range and within that of a particular mistletoe. First the mistletoes are listed alphabetically with the introduced hosts reported for each; the second section is a host index. (Available from Superintendent of Documents, Stock No. GPO 0100-03303, 75 cents.)

HAWKSWORTH, FRANK G.

1975.

Dwarf mistletoe and its role in lodgepole pine ecosystems.

p. 342-358. *In* Manage. Lodgepole Pine Ecosyst. Symp. [Pullman, Wash., Oct. 1973] Proc., 2 vols. David M. Baumgartner, ed. Wash. State Univ., Pullman.

Discusses hosts, distribution, biology, epidemiology, effects, and control of lodgepole pine dwarf mistletoe. Interactions with other elements of the ecosystem are emphasized, including role in forest succession, fire ecology, habitat types, and faunal associates. Yield tables for mistletoe-infested stands are also described.

HAWKSWORTH, FRANK G.

1975.

Tree diseases.

p. 406-407, *In* Yearbook of Science and Technology, 1974. 460 p. McGraw-Hill, N.Y.

Dwarf mistletoes are generally small parasitic plants that live on conifers. Pines are most commonly affected. Growth reduction and mortality are often severe. Control requires pruning infected branches, or removing infected trees or stands.

HAWKSWORTH, FRANK G., JAMES T. FISHER,* AND ROBERT L. MATHIASEN.*

1975.

An unusual occurrence of *Arceuthobium cyanocarpum* on ponderosa pine near Boulder, Colorado.

Plant Dis. Rep. 59(9):758-759.

This dwarf mistletoe usually parasitizes limber pine. It was found more than 2,000 feet lower and 5 miles away from the closest known populations of this taxon on limber pine. The common ponderosa pine dwarf mistletoe also occurs in the stand, and some trees are parasitized by both dwarf mistletoes.

HAWKSWORTH, FRANK G., AND MELVYN J. WEISS.*

1975.

***Arceuthobium gillii* in New Mexico.**

Southwest. Nat. 20(3):418.

Extends the known range of Chihuahua pine dwarf mistletoe from Arizona and Mexico into extreme southwestern New Mexico in the Animas mountains.

LIGHTLE, PAUL C., AND FRANK G. HAWKSWORTH.

1973.

Control of dwarf mistletoe in a heavily used ponderosa pine recreation forest: Grand Canyon, Arizona.

USDA For Serv. Res. Pap. RM-106, 22 p.

Describes the control effort, and compares treated and untreated stands after 20 years. The original goal -- to reduce the level of dwarf mistletoe and protect the ponderosa pine forest -- has been achieved. Recommendations for dwarf mistletoe control in recreational forests are summarized.

LIGHTLE, PAUL C., AND ESLIE H. LAMPI.*

1973.

Herbicides ineffective in controlling southwestern dwarf mistletoe.

USDA For. Serv. Res. Note RM-242, 3 p.

The oil-soluble amine and butoxyethanol ester of

2,4,5-trichlorophenoxy butyric acid (4-(2,4,5,-TB)) in concentrations of 0.5, 1.5, and 3.0 percent were ineffective in reducing infection levels of the parasite in ponderosa pine trees in northern New Mexico.

LIGHTLE, PAUL C., AND MELVYN J. WEISS.*
1974.
Dwarf mistletoe of ponderosa pine in the Southwest.
U.S. Dep. Agric., For. Pest Leafl. 19, 8 p. (Rev.)
Southwestern dwarf mistletoe spreads slowly through stands of ponderosa pine. Growth is retarded, and trees die slowly. Explosive discharge of fruits is responsible for nearly all spread. Characteristic witches' brooms indicate infection. Only silvicultural control methods are available.

MARK, WALTER R.,* AND FRANK G. HAWKSWORTH.
1974.
How important are bole infections in spread of ponderosa pine dwarf mistletoe.
J. For. 72:146-147.
Infections on boles over 5 inches in diameter seem to pose little threat to surrounding trees. Thus larger trees with only bole infections, or bole infections plus prunable light branch infections, need not be removed in control operations.

MC CARTNEY, WILLIAM O.,* ROBERT F. SCHARPF,* AND FRANK G. HAWKSWORTH.
1973.
Additional hosts of *Viscum album*, European mistletoe, in California.
Plant Dis. Rep. 57:904.
Records the occurrence of this mistletoe on 12 more hosts, 3 of which are native California trees, plus 2 hosts determined by inoculation.

SCHARPF, ROBERT F.,* AND FRANK G. HAWKSWORTH.
1974.
Mistletoes on hardwoods in the United States.
U.S. Dep. Agric. For. Pest Leafl. 147, 7 p.
Trees heavily infected with mistletoe are weakened, reduced in growth, and sometimes killed. Weakened trees are predisposed to attack by insects, disease, and drought. Control in forests is difficult. On individual trees, infected limbs can be pruned off, or mistletoe shoots can be broken off periodically.

Mycorrhizal Relationships

RIFFLE, J. W.
1972.
Histopathology of *Pinus ponderosa* ectomycorrhizae infected with a *Meloidogyne* species.
Phytopathology 62:785. (Abstr.)
The undescribed nematode was found infecting ectomycorrhizae of mature ponderosa pine in southwestern New Mexico in 1963.

RIFFLE, JERRY W.
1973.
Histopathology of *Pinus ponderosa* ectomycorrhizae infected with a *Meloidogyne* species.
Phytopathology 63:1034-1040.
Nematode larvae penetrated the ectomycorrhizae, migrated to the stelar region, and developed into adults with their heads embedded in vascular tissue. Giant cells developed near the head, distorting and crushing xylem tracheids in the vicinity.

RIFFLE, JERRY W.
1973.
Pure culture synthesis of ectomycorrhizae on *Pinus ponderosa* with species of *Amanita, Suillus,* and *Lactarius*.
For. Sci. 19:242-250.
Mycorrhizae were formed during a 5-month period with *Suillus granulatus, Amanita muscaria, A. pantherina,* and *Lactarius deliciosus*. Morphological-anatomical characteristics of these mycorrhizae are described. The number of confirmed *P. ponderosa* mycorrhizal symbionts is increased from six to ten.

RIFFLE, JERRY W.
1975.
Two *Aphelenchoides* species suppress formation of *Suillus granulatus* ectomycorrhizae with *Pinus ponderosa* seedlings.
Plant Dis. Rep. 59(12):951-955.
Feeding activities of nematodes stopped or slowed fungal growth and prevented mycelia from coming in contact with many of the roots. Nematodes did not suppress fungus viability, however. Nematodes fed only on fungal mycelia; none were found in roots or mycorrhizal cortical tissue.

Plant Nematodes

RIFFLE, JERRY W.
1972.
Effect of certain nematodes on the growth of *Pinus edulis* and *Juniperus monosperma* seedlings.
J. Nematol. 4:91-94.
Hoplolaimus galeatus, Helicotylenchus pumulis, Tylenchus exiguus, and *Xiphinema americanum* parasitized *P. edulis* seedlings but did not significantly reduce seedling growth. *Xiphinema americanum* and *H. pumulis* parasitized *J. monosperma* seedlings and reduced root weights, root collar diameters, and stem weights. *H. galeatus* and *H. pumulis* entered the seedling roots of both tree species and fed as endoparasites.

RIFFLE, JERRY W.
1973.
Effect of two mycophagous nematodes on *Armillaria mellea* root rot of *Pinus ponderosa* seedlings.
Plant Dis. Rep. 57:355-357.
Aphelenchoides cibolensis and *A. composticola* in flask cultures suppressed development of *Armillaria mellea* root rot of *Pinus ponderosa*. Nematodes greatly reduced mortality due to root rot, and generally reduced seedling weight losses, but neither species killed the fungus.

Non-pathogenic Diseases

SPOTTS, ROBERT A.,* JACK ALTMAN,* AND JOHN M. STALEY.
1972.
Soil salinity related to ponderosa pine tipburn.
Phytopathology 62:705-708.
Symptoms identical to those occurring naturally in Denver were induced with a variety of chloride salt solutions. Induced needle injury and foliar concentration of chloride were highly correlated. Total soluble salt and chloride levels were higher in soils around injured pines than around healthy pines.

Insect Detection, Evaluation, Identification

STEIN, JOHN D., AND PATRICK C. KENNEDY.
1972.
Key to shelterbelt insects in the northern Great Plains.
USDA For. Serv. Res. Pap. RM-85, 153 p.

An insect key designed to help identify 227 insect species. The text contains 136 figures and 8 color plates to aid in identification. Several tables assist in coordinating host damage with a particular insect species.

STEIN, JOHN D.
1974.
Introduction to shelterbelt insects.
Proc. Entomol. Soc. Am., North Cent. Branch 28:197-198. (Abstr.)
Caragana blister beetle, woolly elm aphid, boxelder twig borer, poplar petiolegall aphid, and fall cankerworm were rated most damaging in North Dakota. Western pine tip moth threatens pine plantings in the central Plains, and an elm leaf beetle is serious in central and southern Plains.

STEIN, JOHN D.
1974.
Sampling defoliators in single row shelterbelts.
Proc. Entomol. Soc. Am., North Cent. Branch 28:199. (Abstr.)
Two half-meter twigs from the upper half of the tree was the most effective method of predicting defoliation levels. An average of 36 twigs per belt were required to make a correct prediction.

STEIN, JOHN D., AND DENNIS J. DORAN.
1975.
A nondestructive method of whole-tree sampling for spring cankerworm.
USDA For. Serv. Res. Note RM-290, 4 p.
The use of a backpack mistblower and a pyrethrum compound facilitates whole tree sampling without destroying the trees. This method can be used as a collecting tool or as a means of determining density and distribution of insect populations.

STEIN, JOHN D.
1976.
Insects: A guide to their collection, identification, preservation, and shipment.
USDA For. Serv. Res. Note RM-311, 12 p.
Homeowners can send insects to their State extension entomologist for identification. The basic requirements for proper collection, preservation, and shipment of insects are summarized briefly here. A reference table lists 184 typical or prevalent insects associated with 52 tree and schrub hosts found in North and South Dakota.

Bark Beetles

BUFFAM, P. E.,* C. K. LISTER,* R. E. STEVENS, AND R. H. FRYE.*
1973.
Fall cacodylic acid treatments to produce lethal traps for spruce beetles.
Environ. Entomol. 2:259-262.
Cacodylic acid, applied to basal frills on *Picea engelmannii*, resulted in trap trees lethal to *Dendroctonus rufipennis*. Green trees were treated and felled in September and October; beetles attacking the following summer produced significantly fewer progeny than untreated checks.

LUCHT, D. D.,* R. H. FRYE,* AND J. M. SCHMID.
1974.
Emergence and attack behavior of *Dendroctonus adjunctus* Blandford near Cloudcroft, New Mexico.
Ann. Entomol. Soc. Am. 67:610-612.
Most beetles emerge about 1 year after the parent adults attack. Peak numbers were recorded in the last week of October. A second emergence peak occurs about 2 years after the original attacks. Around 90 percent of the brood completes development in 1 year while the remaining 10 percent mature in 2 years.

MATA, S. A., JR.
1972.
Accuracy of determining mountain pine beetle attacks in ponderosa pine utilizing pitch tubes, frass, and entrance holes.
USDA For. Serv. Res. Note RM-222, 2 p.
Counts of external indicators of attacks by the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, throughout the infested length of five sampled ponderosa pines, were 1.5 percent greater than actual attacks.

MC CAMBRIDGE, WILLIAM F., AND FRED B. KNIGHT.
1972.
Factors affecting spruce beetles during a small outbreak.
Ecology 53:830-839.
After a 2-year epidemic, reduced beetle fecundity, due to nematodes and unknown agents, was the first indicator of outbreak decline. Significant summer mortality agents were pitch, competition for food, predation by woodpeckers and flies, and parasitism by wasps. Woodpecker activity caused desiccation of both food and beetle larvae.

MC CAMBRIDGE, WILLIAM F., AND GALEN C. TROSTLE.*
1972.
The mountain pine beetle.
U. S. Dep. Agric. For. Pest Leafl. 2, 6 p. (Rev.)

MC CAMBRIDGE, W. F.
1972.
Treatment height for mountain pine beetles in Front Range ponderosa pine.
USDA For. Serv. Res. Note RM-218, 2 p.
Pitch tubes and intermittent blue stain are generally found about 5 feet above the highest point where significant mountain pine beetle brood is produced; thus, chemical control can be achieved by spraying to 5 feet below the highest pitch tubes.

MC CAMBRIDGE, WILLIAM F.
1974.
Identifying ponderosa pine infested with mountain pine beetles.
USDA For. Serv. Res. Note RM-273, 2 p.
Trees successfully and unsuccessfully attacked by mountain pine beetles have several symptoms in common, so that proper diagnosis is not always easy. Guidelines presented here enable the observer to correctly distinguish nearly all attacked trees.

MC CAMBRIDGE, W. F.
1974.
Influence of low temperatures on attack, oviposition, and larval development of mountain pine beetle, *Dendroctonus ponderosae* (Coleoptera: Scolytidae).
Can. Entomol. 106:979-984.
Mountain pine beetles attacked logs, mated, and constructed egg galleries slowly at 4.4 C. No eggs were deposited in 6 weeks. Attack and oviposition increased above this temperature. Larvae grew at 4.4 C. Growth at 2.2 C is difficult to prove because of very high mortality among smallest individuals.

MC CAMBRIDGE, WILLIAM F., JOHN LAUT,* AND RON GOSNELL.*
1975.
Fumigate firewood infested with mountain pine beetle.
USDA For. Serv. Res. Note RM-289, 2 p.
Beetles in ponderosa pine firewood can be killed by spraying each cord with 2 gallons of ethylene dibromide emulsion, then covering and sealing the piles with plastic.

MC KNIGHT, M. E., AND D. G. AARHUS.*
1973.
Bark beetles, *Leperisinus californicus* and *L. criddlei* (Coleoptera: Scolytidae), attacking green ash in North Dakota.

Ann. Entomol. Soc. Am. 66:955-957.

Lesperisinus californicus Swaine breeds only in living tissue, usually pruning branches, but it sometimes invades tree boles, causing tree mortality. *L. criddlei* Swaine attacks cut trees, broken branches, trees girdled by rodents, and limbs or stems girdled earlier by *L. californicus*.

MITCHELL, J. C., AND J. M. SCHMID.
1973.
Spruce beetle: Mortality from solar heat in cull logs of Engelmann spruce.
J. Econ. Entomol. 66:401-403.

Solar treatment of naturally infested spruce cull logs in clearcuts gave 90 percent or greater mortality of *Dendroctonus rufipennis* on the top surface of turned logs, but did not significantly increase mortality on their sides. Solar treatment was most effective if logs were turned before July.

SARTWELL, CHARLES,* AND ROBERT E. STEVENS.
1975.
Mountain pine beetle in ponderosa pine: Prospects for silvicultural control in second-growth stands.
J. For. 73:136-140.

Severe tree killing occurs predominantly in dense stands where competition has substantially slowed growth of even the dominant trees. Early results of experiments begun in the 1960's indicate that thinning dense stands deserves major emphasis in efforts to minimize this pest problem.

SCHMID, J. M.
1972.
A problem in the Front Range: Pine beetles.
Colo. Outdoors 21(6):37-39.

Characteristics of infested trees and the life cycle of the beetle are briefly stated. Natural control factors and current control methods are discussed. Long term stability and future status of beetle populations is proposed.

SCHMID, J. M.
1972.
Reduced ethylene dibromide concentrations or fuel oil alone kills spruce beetles.
J. Econ. Entomol. 65:1520-1521.

No living beetles were found in bolts treated with ethylene dibromide at 0.25 pound per 5 gallons of fuel oil (1/6 of current recommendations). Fuel oil alone killed 90 percent of the brood in larval or pupal stages.

SCHMID, J. M., AND ROY C. BECKWITH.*
1972.
The spruce beetle.
U. S. Dep. Agric. For. Pest Leafl. 127, 7 p.

The spruce beetle annually kills 300-500 million board feet of spruce. Overmature trees are usually attacked first, but all diameter classes may be killed. Most outbreaks originate in blowdowns, but cull logs may also be a contributing factor.

SCHMID, J. M.
1972.
Emergence, attack densities, and seasonal trends of mountain pine beetle *(Dendroctonus ponderosae)* in the Black Hills.
USDA For. Serv. Res. Note RM-211, 7 p.

Beetles began emerging around July 1 and emerged in peak numbers on August 15, 1966 and 1967. Adults emerged almost simultaneously from north and south sides of trees. Relationships between beetle emergence, evaluation techniques, and control operations are discussed.

SCHMID, J. M., AND ROY C. BECKWITH.*
1975.
The spruce beetle.
U.S. Dep. Agric. For. Pest Leafl. 127, 7 p. (Slightly rev.)

The spruce beetle annually kills 300-500 million board feet of spruce. Overmature trees are usually attacked first, but all diameter classes may be killed. Most outbreaks originate in blowdowns, but cull logs may also be a contributing factor. (Slightly revised from 1972 issue.)

SCHMID, J. M., AND R. H. FRYE.*
1976.
Stand ratings for spruce beetles.
USDA For. Serv. Res. Note RM-309, 4 p.

Engelmann spruce-subalpine fir stands can be rated for potential spruce beetle (*Dendroctonus rufipennis* (Kirby)) outbreaks on the basis of physiographic location, tree diameter, basal area, and percentage of spruce in the canopy.

STEVENS, ROBERT E.
1972.
Use of silviculture in control of bark beetles (Scolytidae).
VII Nac. Congr. Mex. Entomol. [Mex. City, Oct. 1970] Folia, Nums. 23-24, p. 87-88.

Carefully controlled logging offers a good way to change the conditions under which insect outbreaks develop. This approach is longlasting, safe, and ecologically harmonious.

STEVENS, ROBERT E.
1973.
Association of *Pityophthorus opimus* with *Pissodes terminalis* in Colorado lodgepole pine (Coleoptera: Scolytidae and Curculionidae).
Coleopt. Bull. 27:141-142.

These observations constitute new host and locality records for *P. opimus*, and also indicate an example of commensalism between the two beetle species.

STEVENS, ROBERT E., AND HAROLD W. FLAKE, JR.
1974.
A roundheaded pine beetle outbreak in New Mexico: Associated stand conditions and impact.
USDA For. Serv. Res. Note RM-259, 4 p.

Dendroctonus adjunctus Blandford infests *Pinus ponderosa* Laws. in mixed second-growth stands in the Sacramento Mountains of south-central New Mexico. In six areas, losses ranged from near 0 to over 50 percent of the ponderosa pine stand component, both in number of trees and basal area.

STEVENS, ROBERT E., CLIFFORD A. MYERS, WILLIAM F. MC CAMBRIDGE, GEORGE L. DOWNING,* AND JOHN G. LAUT.*
1974.
Mountain pine beetle in Front Range ponderosa pine: What it's doing and how to control it.
USDA For. Serv. Gen. Tech. Rep. RM-7, 3 p.

Mountain pine beetle is currently in outbreak status in Rocky Mountain ponderosa pine stands. The cause is partly related to extensive areas of susceptible forest. Combined control programs using all suitable methods are proposed.

STEVENS, ROBERT E., DONN B. CAHILL,* C. KENDALL LISTER,* AND GARY E. METCALF.*
1974.
Timing cacodylic acid treatments for control of mountain pine beetles in infested ponderosa pines.
USDA For. Serv. Res. Note RM-262, 4 p.

Careful timing is critical to success. Infested trees must be treated before any larval galleries exceed 0.5 inch in length. Since the beetle attack period may last more than 1 month, more than one visit per area will be necessary to locate and properly treat all trees that become infested.

Defoliators

STEIN, JOHN D.
1974.
Elm sawfly.
U.S. Dep. Agric., For. Pest Leafl. 142, 6 p.
Elm sawfly larvae sporadically cause serious defoliation of elms and willows, particularly in urban areas. The large adults gash the bark of small limbs and branches with powerful mandibles to feed on sap.

STEIN, JOHN D.
1974.
Spring cankerworm (*Paleacrita vernata*) (Lepidoptera: Geometridae) feeding on flax as a secondary host.
Can. Entomol. 103:783-784.
After the larvae completely defoliated a Siberian elm shelterbelt in North Dakota, they migrated into a flax field, continued to develop, and pupated in the soil.

STEIN, JOHN D.
1974.
Unusual oviposition sites of *Paleacrita vernata*.
J. Kans. Entomol. Soc. 47:483-485.
Unusual oviposition sites for the spring cankerworm are noted.

STEIN, JOHN D.
1974.
Pupal distribution of the spring cankerworm.
Proc. Entomol. Soc. Am., North Cent. Branch 29:181-182.
Paleacrita vernata spends about 85 percent of its life cycle in the soil. In Siberian elm shelterbelts, 80 percent of the pupae were within 2 m of tree root collars, and 90 percent were at a depth of less than 11 cm.

STEVENS, ROBERT E.
1973.
A ponderosa pine needle miner in the Colorado Front Range.
USDA For. Serv. Res. Note RM-228, 3 p.
A population of *Coleotechnites* needle miners (Lepidoptera: Gelechiidae) caused noticeable defoliation to ponderosa pines in the Boulder area in 1971 and 1972. Life history and habits are similar to those reported for *C. pinella* Busck. Serious tree injury is not expected.

STEVENS, ROBERT E.
1974.
Ponderosa pine needle miners in Colorado.
Proc. Entomol. Soc. Am., North Cent. Branch 28:198. (Abstr.)
Coleotechnites needle miners have been occasionally reported from Colorado since soon after the turn of the century. A current infestation occurs in a narrow band (200-300 ft) at about 6,800 ft in the Front Range of the Colorado Rockies near Boulder.

Borers, Sucking Insects, and Others

BENTON, TERESA A., AND DANIEL T. JENNINGS.
1975.
Pupal anomaly of *Rhyacionia neomexicana* (Olethreutidae).
J. Lepid. Soc. 29(3):192-194.
A female southwestern pine tip moth pupa with an abnormally segmented abdomen was found in the San Juan National Forest in southwestern Colorado. Reports of such anomalies on lepidopterous pupae are rare.

BREWER, J. W.,* AND ROBERT E. STEVENS.
1972.
Biology of the pinyon pitch nodule moth in Colorado.
J. Colo.-Wyo. Acad. Sci. 7:68-69. (Abstr.)
Petrova albicapitana arizonensis emerges and begins oviposition on new pinyon foliage in mid-July. Larvae mine portions of shoots, which curl like a shepherd's crook, then break off. A pitch nodule at point of entrance provides lasting evidence of infestation.

BREWER, J. WAYNE,* AND ROBERT E. STEVENS.
1973.
The pinyon pitch nodule moth in Colorado.
Ann. Entomol. Soc. Am. 66:789-792.
Petrova arizonensis kills shoots and disrupts normal growth of pinyon. Although tops are stunted, lateral growth continues, and the tree maintains a generous complement of foliage overall. The moth has a 1-year life cycle, overwintering as larvae inside pitch nodules.

FLAKE, HAROLD W., JR.,* AND DANIEL T. JENNINGS.
1974.
A cultural control method for pinyon needle scale.
USDA For. Serv. Res. Note RM-270, 4 p.
Washing eggs off host trees is a simple, inexpensive, effective cultural control method. Dislodged eggs, litter, and debris are raked, bagged, and destroyed. Control must be timed to coincide with the egg stage before crawler emergence.

JENNINGS, DANIEL T.
1974.
Potential fecundity of *Rhyacionia neomexicana* (Dyar) (Olethreutidae) related to pupal size.
J. Lepid. Soc. 28:131-136.
Overwintering female southwestern pine tip moth pupae have a mean ovariole complement of 293 oocytes. Oocyte complements for overwintering pupae can be estimated from pupal size measurements.

JENNINGS, DANIEL T.
1974.
Sexing southwestern pine tip moth pupae, *Rhyacionia neomexicana* (Lepidoptera: Olethreutidae).
Ann. Entomol. Soc. Am. 67:142-143.
Pupae of *Rhyacionia neomexicana* (Dyar) can be sexed by location of the genital opening, ventral abdominal coloration pattern, and relative antennal length.

JENNINGS, DANIEL T.
1975.
Distribution of *Rhyacionia neomexicana* eggs within ponderosa pine trees.
Ann. Entomol. Soc. Am. 68(6):1008-1010.
Eggs of the southwestern pine tip moth are deposited on the inner surfaces of needles in upper crowns of small pines. Most eggs are found about 1.5 cm above the needle-fascicle base, on the three uppermost whorls of foliage. Ovipositing females seem to prefer 1-yr-old needles.

JENNINGS, DANIEL T.
1975.
Life history and habits of the southwestern pine tip moth, *Rhyacionia neomexicana* (Dyar) (Lepidoptera: Olethreutidae).
Ann. Entomol. Soc. Am. 68:597-606.
This moth overwinters in cocoons attached to root collars of ponderosa pine. Emerging females mate once in April. Eggs are usually laid in the upper three whorls of foliage. Eggs hatch in June, and larvae pass through five instars and three feeding stages: needle mining, pitch tent and shoot mining.

MC CAMBRIDGE, WILLIAM F.
1974.
Pinyon needle scale.
U.S. Dep. Agric. For. Pest Leafl. 148, 4 p.
Damage from this sap-sucking insect can be especially serious on esthetically valuable pinyons. Natural controls are generally ineffective, but valuable trees can be protected by spraying with a dimethoate-water emulsion.

MC KNIGHT, M. E., AND A. D. TAGESTAD.
1972.
***Megachile centuncularis* nest in carpenterworm gallery.**
J. Kans. Entomol. Soc. 45:51-53.
A nest of a leafcutter bee was found in a larval gallery of the carpenterworm, *Prionoxystus robiniae* (Peck), in green ash. Damage by this or other species of *Megachile* is common on trees in shelterbelts.

MC KNIGHT, M. E., AND D. G. AARHUS.*
1973.
Notes on weevils from trees and shrubs in North Dakota.
USDA For. Serv. Res. Note RM-230, 4 p.
The red elm bark weevil, the poplar-and-willow borer, an ash seed weevil, the strawberry root weevil, the sweetclover weevil, the lesser alfalfa weevil, and an acorn weevil are widespread and abundant on their respective tree hosts.

MC KNIGHT, M. E., AND SCOTT TUNNOCK.*
1973.
The borer problem in green ash in North Dakota shelterbelts.
N. D. Farm Res. Bimon. Bull. 30(5):8-14.
The probability of damage by the ash borer and the carpenterworm is high, but should not prevent planting where green ash is needed. Effective control involves surveillance, detection, and suppression. Suppression may include insecticides and/or cutting infested trees.

SEXSON, GARY D.,* AND ROBERT E. ROSELLE.*
1974.
Effectiveness of systemic insecticides against the pine tip moth on ponderosa pine.
USDA For. Serv. Res. Note RM-277, 5 p.
Carbofuran 10 percent granules and phorate 15 percent granules (10 pounds active ingredient per acre) were superior for protection of nursery stock against *Rhyacionia bushnelli*. Carbofuran wettable powder (0.25 percent) or dimethoate emulsifiable concentrate (0.125 percent) sprays performed well in nurseries and plantings. Timing of dimethoate applications is critical.

STEVENS, ROBERT E., AND JERRY A. E. KNOPF.*
1974.
Lodgepole terminal weevil in interior lodgepole forests.
Environ. Entomol. 3:998-1002.
Pissodes terminalis is a widespread associate of *Pinus contorta* in the central Rocky Mountain and Intermountain areas. Life history and habits are similar to those reported for the species elsewhere. Infestations are heaviest in stands 5-20 ft tall, and decline as trees grow out of this height class.

TUNNOCK, SCOTT,* AND ARDEN TAGESTAD.
1973.
Incidence of wood borer activity in green ash windbreak plantings in North Dakota.
U.S. Dep. Agric., For. Serv., Reg. One, Div. State Priv. For. Rep. 73-5, 13 p. Missoula, Mont.
The carpenterworm can be considered a minor problem in the eastern half of North Dakota. However, the presence of the ash borer in more than half the windbreaks sampled Statewide makes this insect a potential threat to their management. Control measures are available and should be applied where owners are concerned. (Request for copy may be sent to Forest Pest Control Branch, State and Private Forestry, U.S. Forest Service, Federal Building, Missoula, Montana, 59801.)

Insect Parasites, Predators

HOFF, C. CLAYTON,* AND DANIEL T. JENNINGS.
1974.
Pseudoscorpions phoretic on a spider.
Entomol. News 85:21-22.
Two female *Lustrochernes grossus* (Banks) (Chernetidae) were found on the abdomen of a male giant crab spider, *Olios fasciculatus* in Arizona. This is the first report of pseudoscorpions phoretic on a spider.

JENNINGS, DANIEL T.
1972.
An overwintering aggregation of spiders (Araneae) on cottonwood in New Mexico.
Entomol. News 83:61-67.
An overwintering aggregation of 21 spiders was found beneath the starting bark of a Fremont cottonwood limb in Bernalillo County.

JENNINGS, DANIEL T.
1973.
Egg retreat of *Metaphidippus arizonensis* (Peckham) (Araneae: Salticidae) in a hollow stem.
Entomol. News 84:317-320.
Describes the collection of a jumping spider egg retreat spun within the confines of a dry, hollow composite stem.

JENNINGS, DANIEL T.
1974.
Crab spiders (Araneae: Thomisidae) preying on scarab beetles (Coleoptera: Scarabaeidae).
Coleopt. Bull. 28:41-43.
Xysticus apachecus Gertsch crab spiders were collected feeding on adult *Diplotaxis* sp., *D. parvicollis* Fall, and *Phyllophaga (Listrochelus) falsa* (LeConte) scarab beetles on young *Pinus ponderosa* Laws. trees in Arizona. New records of prey, spider-habitat associations, and predators of scarab beetles are established by these collections.

JENNINGS, DANIEL T., AND HERBERT ALLEN PASE, III.*
1975.
Spiders preying on *Ips* bark beetles.
Southwest. Nat. 20(2):225-229.
Two female *Oxyopes scalaris* were observed feeding on male and female *Ips pini* bark beetles while guarding egg sacs on ponderosa pine in Arizona. A cadaver of a male *I. pini* was found ensnared in the web of a female *Theridion goodnightorum*.

MASSEY, CALVIN L., AND NOEL D. WYGANT.
1973.
Woodpeckers: Most important predators of the spruce beetle.
Colo. Field Ornithol. No. 16, p. 4-8.
Northern three-toed, Hairy, and Downy woodpeckers have destroyed as much as 75 percent of the beetle population in spruce beetle outbreaks. Woodpecker abundance may reach 30 to 45 per acre where infested trees are numerous.

MASSEY, CALVIN L.
1974.
Biology and taxonomy of nematode parasites and associates of bark beetles in the United States.
U. S. Dep. Agric. Agric. Handb. 446, 233 p.
Includes descriptions of 32 parasites and 112 associates, many of which are new to science. For the most part, life histories of the parasites are synchronized with their host. Adult parasites are usually produced in adult beetles. Many of the parasites sterilize their host. Further research is indicated to explore several approaches to biological control of bark beetles with nematodes.

MC KNIGHT, M. E.
1973.
Parasitoids reared from collections of *Rhyacionia bushnelli* from the Great Plains (Lepidoptera: Olethreutidae).

J. Kans. Entomol. Soc. 46:139-143.

Collections of larvae and pupae of *Rhyacionia bushnelli* Busck, the western pine tip moth, from various locations in Kansas, Nebraska, South Dakota, North Dakota, and Montana yielded 24 species of parasitoids in seven families of Hymenoptera and one family of Diptera.

MC KNIGHT, M. E.

1974.

Parasitoids of the western spruce budworm in Colorado.

Environ. Entomol. 3:186-187.

Twenty-eight species of primary parasitoids were collected during study of a major budworm outbreak that developed in the late 1950's and collapsed in the early 1960's. Parasitoids were of little importance in determining budworm survival in any age interval except pupa.

TOLIVER, MICHAEL E., AND DANIEL T. JENNINGS.

1975.

Food habits of *Sceloporus undulatus tristichus* Cope (Squamata: Iguanidae) in Arizona.

Southwest. Nat. 20:1-11.

Analyses of 86 stomachs indicate Isoptera are the major food items in late July and August. Predation on the southwestern pine tip moth is apparently insignificant. Four families of insects and ten families of spiders are reported as prey of *Sceloporus* for the first time.

SCHMID, J. M., J. C. MITCHELL, AND M. H. SCHROEDER.*

1973.

Bark beetle emergence cages modified for use as pit traps.

USDA For. Serv. Res. Note RM-244, 2 p.

Bark beetle emergence cages collect numerous ground dwelling insects when modified for use as pit traps.

SCHROEDER, MAX H.*, JAMES C. MITCHELL, AND J. M. SCHMID.

1975.

Modifications in the Malaise insect trap.

USDA For. Serv. Res. Note RM-299, 2 p.

Bronze screen funnel replaces plastic, and a metal frame replaces wood to make the Malaise insect trap more durable and rigid on windswept rangelands.

TAGESTAD, A. D.

1974.

A technique for mounting microlepidoptera.

J. Kans. Entomol. 47:26-30.

An efficient method for mounting small moths is described and illustrated. Styrofoam mounting blocks, cover glass, and acetate circles and strips are utilized.

Experimental Techniques, Equipment

ACCIAVATTI, ROBERT E.,* AND DANIEL T. JENNINGS.

1976.

Locating western spruce budworm egg masses with ultraviolet light.

USDA For. Serv. Res. Note RM-313, 3 p.

Egg masses on 24-inch Douglas-fir branches were located more quickly and accurately with longwave ultraviolet light than with visible light. Most egg masses missed under ultraviolet light were old and parasitized, while almost half of those missed under visible light were new.

FRYE, R. H.,* AND J. M. SCHMID.

1972.

Polypropylene jars improve performance of bark beetle emergence cages.

J. Econ. Entomol. 65:931.

Freezing water won't break polypropylene jars.

JENNINGS, DANIEL T.

1973.

An emergence cage for soil-pupating *Rhyacionia* spp.

USDA For. Serv. Res. Note RM-250, 4 p.

Describes materials, construction, and installation of an inexpensive cage successfully used to determine adult emergence periods for the southwestern pine tip moth, *Rhyacionia neomexicana* (Dyar). The cage can be used to trap other soil-pupating *Rhyacionia* spp.

JENNINGS, DANIEL T.

1975.

A sex-lure trap for *Rhyacionia* tip moths.

USDA For. Serv. Res. Note RM-284, 4 p.

An inexpensive sex-lure trap is constructed from an ice-cream carton and a board supported on a stake. Caged virgin female moths lure low-flying males to the trap.

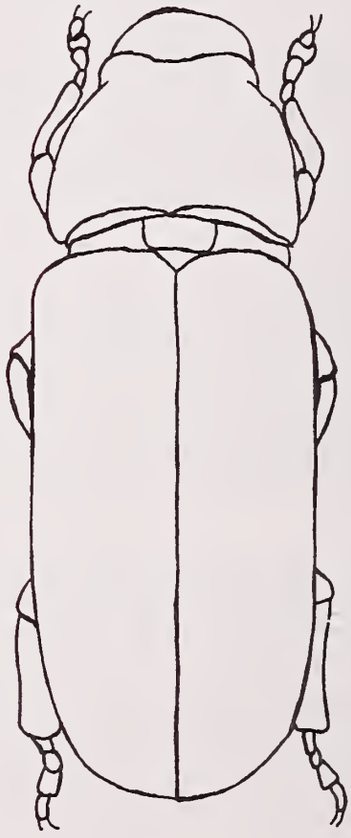
JENNINGS, DANIEL T., AND ROBERT E. ACCIAVATTI.*

1975.

Sexing large aspen tortrix pupae.

USDA For. Serv. Res. Note RM-298, 2 p.

Large aspen tortrix pupae can be sexed by the position and configuration of the genital pore.



FOREST MANAGEMENT

*Private, State or Federal cooperator

Tree Species, Dendrology

JONES, JOHN R., AND DONALD C. MARKSTROM.
1973.
Aspen...an American wood.
U. S. Dep. Agric. FS-217, 8 p.
The most widely distributed tree species in North America, aspen is one of our softer and lighter commercial hardwoods. Largest volumes are used in pulp products. Wood is light colored, straight grained, and finely textured.

MARKSTROM, DONALD C., AND JOHN R. JONES.
1975.
White fir...an American wood.
U.S. Dep. Agric. FS-237, 9 p.
Describes the distribution and growth characteristics of the trees, and the production, properties, and uses of the wood of the six species and two varieties generally referred to as white fir: Pacific silver, white, grand, subalpine, corkbark, California red, Shasta red, and noble.

Tree Physiology, Silvics, Plant Communities

ALEXANDER, ROBERT R., AND W. D. SHEPPARD (SHEPPERD)
1974.
***Ceratonia siliqua* (L.). Carob.**
p. 303-304. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

ALEXANDER, ROBERT R.
1974.
***Ginkgo biloba* L. Ginkgo.**
p. 429-430. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

COCHRAN, P. H.,* AND CARL M. BERNTSEN.
1973.
Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures.
For. Sci. 19:272-280.
Results of growth chamber and field measurements in Oregon support the hypothesis that 'frost pocket' distribution of lodgepole pine in a mosaic with ponderosa pine stands is partly due to greater tolerance of young lodgepole seedlings to low night temperatures. [Request for reprint may be sent to Pacific Northwest Forest and Range Exp. Stn., P. O. Box 3141, Portland, Oreg. 97208.]

FFOLLIOTT, PETER F.,* AND WARREN P. CLARY.
1972.
A selected and annotated bibliography of understory-overstory vegetation relationships.
Ariz. Agric. Exp. Stn. Tech. Bull. 198, 33 p.
The bibliography is organized by five overstory categories: coniferous, deciduous, mixed coniferous-deciduous, shrub, and other. Includes an author index.

JOHNSEN, THOMAS N., JR.,* AND ROBERT A. (R.) ALEXANDER.
1974.
***Juniperus* L. Juniper.**
p. 460-469. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

JONES, JOHN R.
1972.
Moisture stresses in Arizona mixed conifer seedlings.
USDA For. Serv. Res. Pap. RM-86, 8 p.
Seedlings less than about 6 inches tall had higher stresses than larger trees. Nighttime recovery was complete. There was no increasing trend of stresses through the dry season; variability seemed a function of day-to-day weather differences. Species differences were small but significant.

JONES, JOHN R.
1974.
Aspen sucker growing from an Engelmann spruce stump.
USDA For. Serv. Res. Note RM-264, 2 p.
A root from an adjacent aspen entered the base of a spruce stump, grew upward nearly to the top, then back down into the soil on the other side. This path suggests that some mechanism tends to keep lateral aspen roots near the substrate surface. The root later produced a sucker through the top of the stump.

JONES, JOHN R., AND WILLIS J. RIETVELD.
1974.
Occurrence of *Picea pungens* (Pinaceae) near Flagstaff, Arizona.
Southwest. Nat. 19:334-335.
Reports blue spruce in three locations at least 100 km from any previous locations reported, and speculates on possible origins of these stands.

JONES, JOHN R., AND DAVID P. TRUJILLO.
1975.
Height-growth comparisons of some quaking aspen clones in Arizona.
USDA For. Serv. Res. Note RM-282, 4 p.
Three of five pairs of adjacent clones in 70-yr-old aspen stands were of significantly different height. The differences developed in early life. In one pair the difference was large, suggesting possibilities of selecting clonal material for planting.

NOBLE, DANIEL L.
1972.
Effects of soil type and watering on germination, survival, and growth of Engelmann spruce: A greenhouse study.
USDA For. Serv. Res. Note RM-216, 4 p.
Germination was not affected by different soils but increased as amount of water applied monthly increased from none to 1.5 inches. Survival was influenced by soils as well as amount of water received. Top height and total plant dry weight were not significantly related to either soils or watering treatments.

NOBLE, DANIEL L.
1973.
Age of Engelmann spruce seedlings affects ability to

withstand low temperature: A greenhouse study.
USDA For. Serv. Res. Note RM-232, 4 p.

Spruce seedlings were exposed to 5, 15, and 25 F. cold treatments at six development stages--2 weeks through 12 weeks at 2-week intervals. All seedlings survived the 25 F., but no seedlings survived 5 F. At 15 F. few seedlings 2 to 8 weeks old survived, but most seedlings 10 to 12 weeks old survived. No correlation could be found between cold resistance and moisture content.

NOBLE, DANIEL L.
1973.
Engelmann spruce seedling roots reach depth of 3 to 4 inches their first season.
USDA For. Serv. Res. Note RM-241, 3 p.

First-year Engelmann spruce seedlings have an average rooting depth of 3.4 inches, 11 branch roots, and a total root length of 5 inches. Seedlings were field-grown on scarified shaded seedbeds in the central Rocky Mountains, Colorado.

READ, RALPH A.
1974.
***Phellodendron amurense* Rupr. Amur corktree.**
p. 578-579. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

READ, RALPH A.
1974.
***Sapindus drummondii* Hook. and Arn. Western soapberry.**
p. 758-759. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

READ, RALPH A., AND R. L. BARNES.*
1974.
***Morus* L. Mulberry.**
p. 544-547. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

RIETVELD, W. J.
1976.
Hydrophilic polymer reduces germination of ponderosa pine in seed spots.
Tree Plant. Notes 27(1):18-19, 21.

Ponderosa pine seedlings emerged later and in fewer numbers when a hydrophilic polymer was added to seed spots, but survival and height growth of seedlings were unaffected.

RONCO, FRANK.
1972.
Overwinter food reserves of potted Engelmann spruce seedlings.
Can. J. For. Res. 2:489-492.

Lipid, protein, and hemicellulose varied little during the winter. Results did not appear to support an hypothesis that mortality of planted seedlings was caused by overwinter depletion of food reserves.

RONCO, FRANK.
1972.
Solarization--a high elevation problem.
West. Reforestation Coord. Comm. [Seattle, Wash., Dec. 1972] Annu. Meet. 1972:112-115. West. For. Conserv. Assoc., Portland, Oreg.

Photosynthesis may be inhibited by extremely high light intensity. This solarization phenomenon is probably the primary cause of death in Engelmann spruce plantations in the central Rockies. Shade during the first few critical years makes a dramatic difference in seedling color and survival.

RONCO, FRANK.
1973.
Food reserves of Engelmann spruce planting stock.
For. Sci. 19:213-219.

Transplanting reduced dry weight whether seedlings were transplanted in nursery or holding beds. Carbohydrates and hemicelluloses were reduced by transplanting, lipids increased, proteins were not affected. Survival of field-planted trees was not correlated with food reserves.

RONCO, FRANK.
1975.
Diagnosis: 'sunburned' trees.
J. For. 73:31-35.

Failure of Engelmann spruce seedlings to survive when planted in the open at high elevations is apparently due to solarization: intense light inhibits photosynthesis and may subsequently cause death. Successful operational planting techniques are discussed, based on research which indicates that solarization can be eliminated simply by shading.

RUDOLF, PAUL O.,* AND PAUL E. SLABAUGH.
1974.
***Syringa* L. Lilac.**
p. 791-793. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

SCHMID, J. M., AND T. E. HINDS.
1974.
Development of spruce-fir stands following spruce beetle outbreaks.
USDA For. Serv. Res. Pap. RM-131, 16 p.

Seedling regeneration was generally adequate except in heavily logged areas, although seedlings were often damaged, apparently by animals. Species composition was dramatically altered in favor of fir in the unlogged spruce-fir type. In the overstory, fir may predominate for many years, but eventually the spruce will replace it.

TINUS, RICHARD W.
1972.
Carbon dioxide enriched atmosphere speeds growth of ponderosa pine and blue spruce seedlings.
Tree Planters' Notes 23(1):12-15.

Height, caliper, and number of side branches of 1-year-old seedlings grown under 1200 ppm carbon dioxide were greater than for seedlings grown under ambient air. Fresh and dry weights were strikingly greater.

TINUS, RICHARD W.
1974.
Impact of the carbon dioxide requirement on plant water use.
Agric. Meteorol. 14(1/2):99-112.

Land plants lose much water because they must expose photosynthetic tissue to air to obtain carbon dioxide. Succulents which absorb carbon dioxide at night and C-4 plants which lack photorespiration are more efficient. Antitranspirants may reduce water loss. Perhaps water-use efficiency can be increased by breeding.

TINUS, RICHARD W.
1974.
Response of several tree species to day and night temperature.
North Am. For. Biol. Workshop [Fort Collins, Colo., Sept. 1974] Proc. 3:365.

In general, growth of seedlings of Scotch and ponderosa pines,

eastern redcedar, Rocky Mountain juniper, blue spruce, and bur oak was more sensitive to day than to night temperatures.

TINUS, RICHARD W.
1975.
Growth retardants control development of deciduous nursery stock.
Tree Plant. Notes 26(1):5-7.
Two growth retardants were tested for nursery use to control size of five hardwood species. Alar slowed growth of lilac and cotoneaster. SloGro stopped growth of Siberian elm, slowed growth of honeysuckle and cotoneaster. Chemicals were less effective than undercutting on green ash.

VAN DEUSEN, JAMES L., AND LAWRENCE D. BEAGLE.
1973.
Judging ripeness of seeds in Black Hills ponderosa pine cones.
USDA For. Serv. Res. Note RM-235, 4 p.
Buoyancy of cones in water is a good indicator of cone and seed ripeness. When more than half of the cones in a sample from several trees will float, cones in that vicinity should yield a satisfactory number of viable seeds. Frequent checks on specific gravity are needed from mid-August on, since ripening proceeds rapidly then.

WIRSING, JOHN M.,* AND ROBERT R. ALEXANDER.
1975.
Forest habitat types on the Medicine Bow National Forest, southeastern Wyoming: Preliminary report.
USDA For. Serv. Gen. Tech. Rep. RM-12, 12 p.
A vegetation classification based on concepts and methods developed by Daubenmire was used to identify five habitat types and their related phases. A key to identify the habitat types and management implications associated with them are provided.

Genetics, Tree Improvement

CUNNINGHAM, RICHARD A.
1972.
Development of Siberian and Dahurian larches after 10 years in North Dakota.
USDA For. Serv. Res. Note RM-209, 4 p.
Trees were grown from three Siberian larch, one Dahurian larch, and two hybrid larch seed sources. Two Siberian origins may be suitable for windbreak plantings in the Northern Great Plains.

CUNNINGHAM, RICHARD A.
1973.
Scotch pine for the Northern Great Plains.
USDA For. Serv. Res. Pap. RM-114, 12 p.
A provenance test of 49 origins of Scotch pine (*Pinus sylvestris* L.) from eastern Europe, Russia, and Siberia was established at three locations in North Dakota and one in Nebraska. After 10 years (7 in Nebraska), trees from 50 to 55 degrees latitude and 20 to 40 degrees longitude survived best, were taller, and had greener winter foliage. Several provenances appear to be well suited for planting in shelterbelts and for Christmas tree culture.

CUNNINGHAM, RICHARD A.
1975.
Provisional tree and shrub seed zones for the Great Plains.
USDA For. Serv. Res. Pap. RM-150, 15 p.
The Great Plains Region was subdivided into 86 seed collection zones on the basis of soil, topography, water, and climate. Seed should be collected from the zone to be planted, or, if unavailable, from a zone having similar soil and climate. Future provenance test results will be used to determine any need for adjustments in zone boundaries.

DENEKE, FREDERICK J.*, AND RALPH A. READ.
1975.
Early survival and growth of ponderosa pine provenances in east-central Kansas.
USDA For. Serv. Res. Note RM-297, 4 p.
A provenance test of 78 sources of *Pinus ponderosa* was established in 1968 near Junction City. Progeny from the Pacific Northwest and the southern Rocky Mountains performed poorly. Progeny from the northeastern range of the species performed best.

FARNSWORTH, D. H.,* G. E. GATHERUM,* J. J. JOKELA,* H. B. KRIEBEL,* D. T. LESTER,* C. MERRITT,* S. S. PAULEY,* R. A. READ, R. L. SAIDAK,* AND J. W. WRIGHT.*
1972.
Geographic variation in Japanese larch in north central United States plantations.
Silvae Genetica 21:139-147.
Differences in growth rate among seed origins were large, whereas differences in other traits were of little practical significance. Variation in some traits followed a weak geographic pattern, trees from Mts. Asama and Nantai being most exceptional.

READ, RALPH A.
1973.
Seed origins of Scotch pine for Christmas trees in Nebraska.
Am. Christmas Tree J. 17(2):21-26.
Seedlings from 36 origins, primarily from throughout Europe, varied in growth rate, form, and color. Best origins for Christmas tree color in Nebraska are from southern France, Spain, and Turkey. A Scottish origin is recommended for overall desirable characteristics of growth, color, and form.

SPRACKLING, JOHN A., AND RALPH A. READ.
1974.
Jack pine provenance study in eastern Nebraska.
Cent. States For. Tree Improv. Conf. [Ames, Iowa, Oct. 1974] Proc. 9:85-94.
Printed as USDA Forest Service Research Paper RM-143.

SPRACKLING, JOHN A., AND RALPH A. READ.
1975.
Jack pine provenance study in eastern Nebraska.
USDA For. Serv. Res. Pap. RM-143, 8 p.
A 9-year provenance test, with 28 origins, indicated that height, form, cone production, and needle length of southern origins exceeded northern origins. Fast-growing origins developed dense, compact, well-shaped crowns because of the multinodal growth characteristic of jack pine. An Ontario origin is recommended for plantings in Nebraska.

SPRACKLING, JOHN A., AND RALPH A. READ.
1975.
Red pine provenance study in eastern Nebraska.
USDA For. Serv. Res. Pap. RM-144, 7 p.
An 11-year provenance test, with 54 rangewide origins, revealed that heights and growth rates differed significantly among origins, but tree form, needle length, and foliage color were uniform. No geographic patterns of variation were identifiable. A fast-growing Quebec origin is recommended for windbreak and landscape plantings.

TINUS, RICHARD W.
1974.
Grafting ponderosa pine scions on the parent root system.
USDA For. Serv. Res. Note RM-263, 2 p.
Reproductive success is much higher than by direct rooting, and is better distributed over the parent population.

VAN DEUSEN, JAMES L.
1974.
Five-year results of a ponderosa pine provenance study in the Black Hills.

USDA For. Serv. Res. Note RM-278, 4 p.

Data from progeny representing 75 provenances of natural stands in the Great Plains and Northern Rockies showed that trees from no other provenance survived significantly better or grew significantly taller than trees from the Black Hills.

VAN HAVERBEKE, DAVID F., WALTER T. BAGLEY,* AND ELLSWORTH H. BENSON.*

1973.

Breeding a better Christmas tree.

Nebr. Farm, Ranch and Home Q. 20(3):2-4.

Scots pines from seeds from 36 sources in Europe and Asia were planted in eastern Nebraska. Cuttings from trees with best Christmas tree characteristics are grafted onto other seedlings, then intensively managed to develop a seed orchard. Improved seeds should be available in 10 to 15 years.

VAN HAVERBEKE, DAVID F.

1974.

A Scots pine clonal seed orchard of provenance origin. Cent. States For. Tree Improv. Conf. [Ames, Iowa, Oct. 1974] Proc. 9:62-70.

Scions from Scots pines with desirable Christmas tree characteristics were selected from a 36-origin, 7-year-old provenance plantation in Nebraska, and grafted onto potted Scots pine stock. A 1,000-tree clonal seed orchard has been established containing one ramet each of 42 selected ortets.

WRIGHT, JONATHAN W.,* RALPH A. READ, DONALD T. LESTER,* CLAIR MERRITT,* AND CARL MOHN.*

1972.

Geographic variation in red pine: 11-year data from the North Central States.

Silvae Genet. 21:205-210.

Seeds from 91 natural stands and three plantations were tested in eight north-central localities. The 10 fastest growing seedlots grew rapidly at nearly all sites. Thus one set of criteria may suffice for seed procurement and seed orchard development for all the region except the extreme south.

Forest Measurements (Mensuration)

ALEXANDER, ROBERT R., WAYNE D. SHEPPERD, AND CARLETON B. EDMINSTER.

1975.

Yield tables for managed even-aged stands of spruce-fir in the central Rocky Mountains.

USDA For. Serv. Res. Pap. RM-134, 20 p.

Presents procedures for deriving yield tables for managed stands of spruce-fir from data obtained on temporary plots, and the computer programs developed by Myers (1971).

AVERY, CHARLES C.,* FREDERIC R. LARSON, AND GILBERT H. SCHUBERT.

1976.

Fifty-year records of virgin stand development in southwestern ponderosa pine.

USDA For. Serv. Gen. Tech. Rep. RM-22, 71 p.

Ten periodic inventories of an unburned virgin tract of more than 3,000 trees by individual tree records, 2.5-acre subplot summaries of basal area and tree census data, and composite stand tables which display census data;mortality data, and causes, net periodic basal area, volume, and diameter growth.

BEAGLE, LAWRENCE D.

1974.

Cubic-foot volume tables for white spruce in the Black Hills.

USDA For. Serv. Res. Note RM-266, 2 p.

Two tables give volumes in total and merchantable cubic feet. Total volumes include all stemwood from ground line to tip of tree, while merchantable volumes include stemwood from a 1-foot stump to a 4-inch d.i.b. top.

EDMINSTER, CARLETON B., AND FRANK G. HAWKSWORTH.

1976.

User's guide to SWYLD2: Yield tables for even-aged and two-storied stands of southwestern ponderosa pine, including effects of dwarf mistletoe.

USDA For. Serv. Gen. Tech. Rep. RM-23, 8 p.

Describes procedures for application of computer program SWYLD2 (Myers and others, USDA For. Serv. Res. Pap. RM-163, 1976) for yield simulation of even-aged and two-storied stands of southwestern ponderosa pine, including the effects of dwarf mistletoe. SWYLD2 supersedes SWYLD program, published in USDA For. Serv. Res. Pap. RM-87, 1972.

HAWKSWORTH, FRANK G., AND CLIFFORD A. MYERS.

1973.

Procedures for using yield simulation programs for dwarf mistletoe-infested lodgepole and ponderosa pine stands.

USDA For. Serv. Res. Note RM-237, 4 p.

Describes procedures for application of two recently published computer programs for yield simulation of dwarf-mistletoe-infested stands: LPMIST for lodgepole pine in the central Rocky Mountains and SWYLD for ponderosa pine in the Southwest.

MYERS, CLIFFORD A.

1972.

Volume, taper, and related tables for southwestern ponderosa pine.

U. S. For. Serv. Res. Pap. RM-2, 24 p. (Rev.)

Presents volume tables, taper tables, and the distribution of tree volumes among the logs of saw log trees. Volumes are in total cubic feet and cubic feet to a variable top. Tree heights are in feet and numbers of logs.

MYERS, CLIFFORD A., AND ROBERT R. ALEXANDER.

1972.

Bark thickness and past diameters of Engelmann spruce in Colorado and Wyoming.

USDA For. Serv. Res. Note RM-217, 2 p.

Past diameter can be estimated from present diameters and radial wood growth for any desired period. Equation constants account for any periodic change in bark thickness.

MYERS, CLIFFORD A., AND CARLETON B. EDMINSTER.

1972.

Volume tables and point-sampling factors for Engelmann spruce in Colorado and Wyoming.

USDA For. Serv. Res. Pap. RM-95, 23 p.

Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to 6-inch and 8-inch tops, and board feet International 1/4-inch Rule to 6-inch and 8-inch tops. Tree heights are in feet and numbers of logs.

MYERS, CLIFFORD A., FRANK G. HAWKSWORTH, AND PAUL C. LIGHTLE.

1972.

Simulating yields of southwestern ponderosa pine stands, including effects of dwarf mistletoe.

USDA For. Serv. Res. Pap. RM-87, 16 p.

Presents a procedure for computation of yield tables for diseased even-aged stands. Control variables include stand age at time of initial infection and at initial thinning, stocking goals, frequency of thinning, and regeneration system. Stand conditions and severity of infestation change with time and in response to intermediate cuttings.

MYERS, CLIFFORD A., AND CARLETON B. EDMINSTER.

1974.

Conversion of tree-volume equations to the metric system.
USDA For. Serv. Res. Note RM-261, 2 p.
Presents factors for converting volume equations from U.S. Customary to metric units.

MYERS, CLIFFORD A., CARLETON B. EDMINSTER, AND FRANK G. HAWKSWORTH.
1976.
SWYLD2: Yield tables for even-aged and two-storied stands of southwestern ponderosa pine, including effects of dwarf mistletoe.
USDA For. Serv. Res. Pap. RM-163, 25 p.
Possible alternatives for computing yield tables include: even-aged or two-storied, healthy or diseased, and managed or unmanaged stand densities. Stand conditions and severity of dwarf mistletoe change with time and in response to intermediate cuttings. Supersedes Res. Pap. RM-87. A concise user's guide is available as Gen. Tech. Rep. RM-23.

SPRACKLING, JOHN A.
1973.
Soil-topographic site index for Engelmann spruce on granitic soils in northern Colorado and southern Wyoming.
USDA For. Serv. Res. Note RM-239, 4 p.
Site index of Engelmann spruce can be estimated from soil depth to the C horizon and elevation. Predictions should be confined to potential spruce-fir sites on granitic soils in northern Colorado and southern Wyoming.

VAN DEUSEN, JAMES L.
1975.
Estimating breast height diameters from stump diameters for Black Hills ponderosa pine.
USDA For. Serv. Res. Note RM-283, 3 p.
Presents tables and equations to estimate diameter at breast height, outside bark, from inside and outside bark diameters of stumps 6 inches and 1 foot high.

Forest Management Planning

COLORADO STATE UNIVERSITY, COLLEGE OF FORESTRY AND NATURAL RESOURCES.
1972.
Pilot test of program TEVAP for preparation of timber management plans and simulation of a regional data center for decision making in forest management, final report, September 30, 1972.
Colo. State Univ., Coll. For. Nat. Resour., Dep. For. Wood Sci., Fort Collins, Colo., 65 p.
The test was performed by a team consisting of three groups: research, users, and computer services. Results indicate that the programs form a valuable basis for timber management decisionmaking at the National Forest level, and that a regional data center is warranted if management plans are to be updated frequently.

EDWARDS, BRUCE M.,* GARY E. METCALF,* AND W. E. FRAYER.*
1973.
Computer-produced timber management plans: An evaluation of program TEVAP.
USDA For. Serv. Res. Note RM-251, 4 p.
TEVAP (Timber Evaluation And Planning), a computerized timber management planning system, was tested over a 2-year period on the Black Hills National Forest. The system's utility in the decisionmaking process was demonstrated for both broad and local areas.

FFOLLIOTT, PETER F., AND DAVID P. WORLEY.
1973.
Forest stocking equations: Their development and application.
USDA For. Serv. Res. Pap. RM-102, 8 p.
Equations relating proportions of a forest stocked to minimum basal area levels corresponding to each basal area factor used in an inventory can be defined by regression analysis. Equations can be used to help evaluate land treatment potential, determine treatment feasibility, and set operating priorities.

MYERS, CLIFFORD A.
1973.
Simulating changes in even-aged timber stands.
USDA For. Serv. Res. Pap. RM-109, 47 p.
A FORTRAN IV computer program simulates timber management by shelterwood, seed tree, or clearcutting systems. Tree growth, intermediate and regeneration cuts, planting, and catastrophic losses are among changes computed. Annual and periodic costs and returns, analysis of rate earned, and other volumes and values are printed. Supersedes Res. Pap. RM-42.

MYERS, CLIFFORD A.
1974.
Computerized preparation of timber management plans: TEVAP2.
USDA For. Serv. Res. Pap. RM-115, 72 p.
Presents computer programs, written in FORTRAN IV, for analysis of inventory data, and computation of actual and optimum growing stocks and allowable cuts, and other values needed for forest management planning. Computed volumes and areas are summarized in a timber management plan. Effects of cultural operations and other changes are accounted for in computation of both actual and optimum conditions.

Silvicultural Systems

ALEXANDER, ROBERT R.
1972.
Initial partial cutting in old-growth spruce-fir.
USDA For. Serv. Res. Pap. RM-76, 10 p. (Rev.)
Interim guidelines are provided to aid the forest manager in developing alternatives to clearcutting in old-growth spruce-fir forests in Colorado and southern Wyoming. Included are practices for different conditions that should maintain continuous high forest cover to preserve the forest landscape, and that may also be used with small cleared openings to integrate timber production with other key uses. For convenient field use, a smaller, brief version entitled 'Initial partial cutting in old-growth spruce-fir: a field guide' is available as USDA Forest Serv. Res. Pap. RM-76A.

ALEXANDER, ROBERT R.
1972.
Partial cutting practices in old-growth lodgepole pine.
USDA For. Serv. Res. Pap. RM-92, 16 p.
Guidelines are provided to aid the forest manager in developing partial cutting practices to maintain continuous forest cover in travel influence zones, and in areas of high recreational values or outstanding scenic beauty. These guidelines consider stand conditions, windfall risk situations, and insect and disease problems. These cutting practices also may be used in combination with small cleared openings to create the kinds of stands desirable for increased water yields, improvement of wildlife habitat, and to integrate timber production with other uses. On areas where timber production is the primary objective, clearcutting in small, dispersed units is the recommended method of harvesting trees. For convenient field use, a smaller, brief version, 'Partial cutting practices in old-growth lodgepole pine: a field guide' is available as USDA Forest Serv. Res. Pap. RM-92A.

ALEXANDER, ROBERT R.

1973.

Partial cutting in old-growth spruce-fir.

USDA For. Serv. Res. Pap. RM-110, 16 p.

Guidelines aid the forest manager in developing partial cutting practices to convert old-growth spruce-fir forests into managed stands, while maintaining continuous forest cover. These practices can be used in combination with small cleared openings to increase water yields, improve wildlife habitat, and integrate timber production with other uses. Supersedes Res. Pap. RM-76.

ALEXANDER, ROBERT R.

1974.

Silviculture of central and southern Rocky Mountain forests: A summary of the status of our knowledge by timber types.

USDA For. Serv. Res. Pap. RM-120, 36 p.

Summarizes a series of comprehensive reports on the silviculture of lodgepole pine, ponderosa pine, mixed conifer, and spruce-fir timber types. Includes what is known, what can be recommended, and what additional information is needed for each timber type. (Available from Superintendent of Documents, Stock No. GPO 0101-00368.)

ALEXANDER, ROBERT R.

1974.

Silviculture of subalpine forests in the central and southern Rocky Mountains: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-121, 88 p.

The ecology and resource of the Rocky Mountain subalpine forests in Wyoming, Colorado, and New Mexico are briefly described, followed by in-depth reviews of the spruce-fir type and lodgepole pine type. The relevant literature is included, along with unpublished research, observations, and experience. Research needs are considered as well as what is already known. (Available from Superintendent of Documents, Stock No. GPO 0101-00381.)

ALEXANDER, ROBERT R.

1975.

Partial cutting in old-growth lodgepole pine.

USDA For. Serv. Res. Pap. RM-136, 17 p.

Guidelines are provided for partial cutting where continuous forest cover should be maintained. Partial cutting in combination with small cleared openings can increase water yields, improve wildlife habitat, and integrate timber production with other uses. Where timber production is the primary objective, clearcutting in small, dispersed units is recommended.

BOLDT, CHARLES E.

1973.

Central and southern Rocky Mountain types: Black Hills ponderosa pine.

p. 52-53. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 124 p.

Summaries the silvicultural systems that appear biologically feasible for managing Black Hills ponderosa pine. Supporting information is given on extent and characteristics of the type, cultural requirements of component species, and biological factors that control the choice of silvicultural options.

BOLDT, CHARLES E., AND JAMES L. VAN DEUSEN.

1974.

Silviculture of ponderosa pine in the Black Hills: Status of our knowledge.

USDA For. Serv. Res. Pap. RM-124, 45 p.

This Paper, intended as a guide for professional foresters, describes major silvicultural conditions likely to be encountered in the Black Hills, reasonable treatment options, and probable results and implications of these treatments. It also describes silvical characteristics and behavior of Black Hills ponderosa pine, and a variety of proven silvicultural tools. (Available from Superintendent of Documents, Stock No. GPO 0101-00384.)

JONES, JOHN R.

1973.

Central and southern Rocky Mountain types: Rocky Mountain aspen.

p. 49-51. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 124 p.

Summarizes the silvicultural systems that appear biologically feasible for managing Rocky Mountain aspen. Supporting information is given on extent and characteristics of the type, cultural requirements of component species, and biological factors that control the choice of silvicultural options.

JONES, JOHN R.

1973.

Central and southern Rocky Mountain types: Southwestern mixed conifers.

p. 47-49. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 124 p.

Summarizes the silvicultural systems that appear biologically feasible for managing southwestern mixed conifers. Supporting information is given on extent and characteristics of the type, cultural requirements of component species, and biological factors that control the choice of silvicultural options.

JONES, JOHN R.

1974.

Silviculture of southwestern mixed conifers and aspen: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-122, 44 p.

Brings together in one document a discussion of the relevant literature, observations, experience, and unpublished research on the ecology and silviculture of mixed conifers in the interior Southwest. Research needs are also considered. (Available from Superintendent of Documents, Stock No. GPO 0101-00377.)

LOTAN, JAMES E.,* AND ROBERT R. ALEXANDER.

1973.

Northern Rocky Mountain types: Lodgepole pine.

p. 42-44. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric Agric. Handb. 445, 124 p.

Summarizes the silvicultural systems that appear biologically feasible for managing lodgepole pine. Supporting information is given on extent and characteristics of the type, cultural requirements of component species, and biological factors that control the choice of silvicultural options.

SCHMIDT, WYMAN C.,* CHARLES A. WELLNER,* AND ROBERT R. ALEXANDER.

1973.

Northern Rocky Mountain types: Engelmann spruce-subalpine fir.

p. 40-42. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 124 p.

Summarizes the silvicultural systems that appear biologically feasible for managing Engelmann spruce-subalpine fir. Supporting information is given on extent and characteristics of the type, cultural requirements of component species, and biological factors that control the choice of silvicultural options.

SCHUBERT, GILBERT H.

1973.

Central and southern Rocky Mountain types: Southwestern ponderosa pine.

p. 45-46. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 124 p.

Summarizes the silvicultural systems that appear biologically

feasible for managing southwestern ponderosa pine. Supporting information is given on extent and characteristics of the type, cultural requirements of component species, and biological factors that control the choice of silvicultural options.

SCHUBERT, GILBERT H.
1974.
Silviculture of southwestern ponderosa pine: The status of our knowledge.
USDA For. Serv. Res. Pap. RM-123, 71 p.
Economic value, impacts on other uses, and the timber resource are discussed first, followed by ecological background, site quality, growth and yield, and silviculture and management. Relevant literature is discussed along with observations, experience, and results of unpublished research. Research needs are also considered. (Available from Superintendent of Documents, Stock No. GPO 0101-00380.)

SCHUBERT, GILBERT H.
1976.
Silvicultural practices for intensified forest management.
p. 37-54. *In* Trees--The renewable resource. Proc. Rocky Mt. For. Ind. Conf. [Tucson, Ariz., Mar. 1976].
We need to intensify management efforts along three main lines: (1) reduce the time lost in reforesting logged and burned areas, (2) shorten the time required to get replacement trees to commercial sizes by early precommercial thinning, and (3) maintain the desired growth rate throughout the tree's life by properly scheduled intermediate cuts.

Reforestation — Natural Regeneration

JONES, JOHN R., AND DAVID P. TRUJILLO.
1975.
Development of some young aspen stands in Arizona.
USDA For. Serv. Res. Pap. RM-151, 11 p.
A substantial apparent range of genotypes and sites was sampled in aspen stands on a 23-year-old mixed conifer burn. All plots were heavily stocked with aspen suckers by the end of the third summer. Stocking as well as height differed among clones growing together on the same site.

JONES, JOHN R.
1975.
Regeneration on an aspen clearcut in Arizona.
USDA For. Serv. Res. Note RM-285, 8 p.
After four growing seasons mil-acre stocking on a 5-acre clearcut was 98 percent. The tallest on any plot was 17.4 feet. Stocking density was irregular. Thinly stocked spots seemed largely associated with slash concentrations, haul roads, and main skid trails.

RIETVELD, W. J.
1975.
Phytotoxic grass residues reduce germination and initial root growth of ponderosa pine.
USDA For. Serv. Res. Pap. RM-153, 15 p.
Extracts of Arizona fescue and mountain muhly significantly reduced germination of ponderosa pine seeds, and retarded speed of elongation and mean radicle length. Three possible routes of release of the inhibitor were investigated: (1) leaching from live foliage, (2) root exudation, and (3) overwinter leaching from dead residues.

Reforestation—Artificial Regeneration, Nurseries, and Greenhouses

HIATT, HARVEY A., AND RICHARD W. TINUS.
1974.
Container shape controls root system configuration of ponderosa pine.
p. 194-196. *In* North Am. Containerized For. Tree Seedling Symp. [Denver, Colo., Aug. 1974] Proc. Great Plains Agric. Counc. Publ. 68, 458 p.
Ponderosa pines grown in different containers showed some recovery from root coiling after outplanting. Trees grown in containers with no walls had no more coiling than trees grown from seed in place, and seedlings grown in containers with vertical grooves had less coiling than ones grown in smooth-walled containers.

JOHNSEN, THOMAS N., JR.,* GILBERT H. SCHUBERT, AND DEWEY P. ALMAS.*
1973.
Rehabilitation of forest land: The Rocky Mountain-Intermountain Region.
J. For. 71:144-147.
Underlying problem aspects of competition include better: knowledge and use of site evaluations, understanding of basic plant needs and competition, and site-treatment prescriptions.

JONES, JOHN R.
1974.
A spot seeding trial with southwestern white pine and blue spruce.
USDA For. Serv. Res. Note RM-265, 7 p.
Despite abundant germination, favorable slope aspects, absence of heavy herbaceous competition, good cold air drainage, and initial rodent reduction, few seedlings survived to the middle of the third summer. Major known causes of death were frost heaving, predation, and soil burial.

JONES, JOHN R.
1975.
A southwestern mixed conifer plantation--case history and observations.
USDA For. Serv. Res. Pap. RM-148, 8 p.
Ponderosa pine, Douglas-fir, and blue spruce were planted on clearcuttings in east-central Arizona at 9200 ft. Some markedly inferior stock survived and grew poorly. Pines on south slopes that survived a meadow mouse outbreak were vigorous. Blue spruce survived and grew well on north-facing slopes, poorly on south slopes.

RIETVELD, W. J., AND L. J. HEIDMANN.
1974.
Mulching planted ponderosa pine seedlings in Arizona gives mixed results.
USDA For. Serv. Res. Note RM-257, 3 p.
Mulching of 3-0 spring-planted ponderosa pine seedlings on difficult sites with clear and black polyethylene, petroleum-emulsion, volcanic cinders, woodchips, and dead grass sod was generally ineffective.

RIETVELD, W. J., AND L. J. HEIDMANN.
1976.
Direct seeding ponderosa pine on recent burns in Arizona.
USDA For. Serv. Res. Note RM-312, 8 p.
Results of direct seeding are extremely variable, even on favorable sites. Direct seeding recent burns, even by spot seeding, is of limited usefulness in the Southwest. The method should be reserved as a flexible tool to promptly regenerate only the best sites when planting stock is unavailable.

RONCO, FRANK.
1972.
Planting Engelmann spruce.
USDA For. Serv. Res. Pap. RM-89, 24 p.
Reforestation operations covered include storage, transportation, microsite selection, site preparation, planting, plantation protection, and recordkeeping. Physiological and

silvicultural requirements of spruces are discussed with respect to the harsh environment of the spruce-fir zone. Mattock planting and methods of providing shade are emphasized. For convenient field use, a smaller, brief version, 'Planting Engelmann spruce: a field guide' is available as USDA Forest Serv. Res. Pap. RM-89A.

SCHUBERT, GILBERT H., AND JOHN A. PITCHER.*
1973.
A provisional tree seed-zone and cone-crop rating system for Arizona and New Mexico.
USDA For. Serv. Res. Pap. RM-105, 8 p.
The forested areas were divided into 10 physiographic-climatic regions, subdivided into 5 to 9 seed collection zones. Provenance tests will determine need for adjustments. Seed for reforestation should be collected within the zone. A 10-unit classification system for rating cone crops is included.

SLABAUGH, PAUL E.
1974.
Siberian elm seedling development enhanced by wider in-row spacing.
Tree Planters' Notes 25(1):23-24.
A seeding rate that results in row densities of 15 to 20 trees per linear foot at age 2-0, while producing slightly fewer usables, will result in economies in overall production costs.

STEIN, WILLIAM I.,* PAUL E. SLABAUGH, AND A. PERRY PLUMMER.*
1974.
Harvesting, processing, and storage of fruits and seeds. p. 98-125. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Availability of viable seeds to regenerate a variety of trees and shrubs depends on use of sound biological information and proven practices. This chapter covers the concepts and practices proven sound and effective for collecting, processing, and storing small or large quantities of fruits and seeds.

STEIN, WILLIAM I.,* JERRY L. EDWARDS,* AND RICHARD W. TINUS.
1975.
Outlook for container-grown seedling use in reforestation.
J. For. 73:337-341.
The North American Containerized Forest Tree Seedling Symposium at Denver, Colorado, covered the status and technical aspects of container-grown seedling production and use. Current trends, state of knowledge, and problems to solve are covered in this overview of material appearing in the Proceedings.

TINUS, RICHARD W.
1974.
Conifer seedling nursery in a greenhouse.
J. Soil Water Conserv. 29:122-125.
A new greenhouse system for growing containerized tree seedlings avoids many problems of outdoor nurseries. In 1 year, seedlings equal in size 3- to 4-year-old nursery stock grown outdoors on the Great Plains.

TINUS, RICHARD W.
1974.
Large trees for the Rockies and Plains.
p. 112-118. *In* North Am. Containerized For. Tree Seedling Symp. [Denver, Colo., Aug. 1974] Proc. Great Plains Agric. Counc. Publ. 68, 458 p.
Harsh site conditions require large trees in large containers for best survival. The strategy is to grow the seedling rapidly in its optimum environment, and design the growing cycle to deliver the desired size in proper outplanting condition at a specified time. Procedure for growing several species is outlined.

TINUS, RICHARD W.
1974.
Characteristics of seedlings with high survival potential.
p. 276-282. *In* North Am. Containerized For. Tree Seedling Symp. [Denver, Colo., Aug. 1974] Proc. Great Plains Agric. Counc. Publ. 68, 458 p.
To survive, species and seed source must be adapted to the site, the seedlings must be in the proper physiological state to meet the new environment, and root contact with the soil must be quickly established.

TINUS, RICHARD W., WILLIAM I. STEIN,* AND WILLIAM E. BALMER.* (EDITORS)
1974.
Proceedings of North American Containerized Forest Tree Seedling Symposium, Denver, Colo., August 26-29, 1974.
Great Plains Agric. Counc. Publ. 68, 458 p.
The status of our knowledge about how to grow containerized forest tree seedlings is summarized in 76 papers grouped under: development and objectives of containerization, seedling production in controlled environments, containers and handling systems, nursery procedures and problems, engineering container systems, field performance, container programs around the world, economics of containerized forestation, and the challenges ahead.

TINUS, RICHARD W.
1975.
Are bare root nurseries obsolete?
Int. Nurserymen's Assoc. [Missoula, Mont., Aug. 1975] Proc. n.p. [4 p.] Div. For., Dep. Nat. Resour. Conserv., Missoula, Mont.
The question is answered by comparing the performance of bare-root and containerized nurseries in meeting the requirements of tree seedlings and those who plant them.

TINUS, RICHARD W.
1975.
Container planting in the West.
Southeast. Nurserymen's Conf. [Nacogdoches, Tex., July 1974] Proc. 1974:43-47. Southeast. Area, U.S. Dep. Agric., For. Serv., Atlanta, Ga.
Production of container-grown tree seedlings is increasing rapidly, particularly along the West Coast. Economics (West Coast) and better survival under harsh conditions (Interior West) are primary reasons. Variations in operations are discussed.

TINUS, RICHARD W.
1975.
Observations and new information on greenhouse container systems.
Int. Nurserymen's Assoc. [Missoula, Mont., Aug. 1975] Proc. n.p. [10 p.] Div. For., Dep. Nat. Resour. Conserv., Missoula, Mont.
Summarizes new design and operation techniques learned from recent experiences.

TINUS, RICHARD W.
1975.
The place of container seedlings in nursery production programs.
Servicewide Conf. on Plant. Stock Prod. [Coeur d'Alene, Idaho, Sept. 1975] Proc., p. 129-138. Div. Timber Manage., U.S. Dep. Agric., For. Serv., Wash., D.C.
Container stock should be used (1) when it can save nursery costs, (2) when timing of planting is such that survival of bare-root stock would be poor, (3) when survival must be improved on harsh sites, and (4) when stock from a particular seed source is needed quickly.

Timber Stand Improvement

WOLLUM, A. G., II,* AND GILBERT H. SCHUBERT.
1975.
Effect of thinning on the foliage and forest floor properties of ponderosa pine stands.
Soil Sci. Soc. Am. Proc. 39(5):968-972.
Although the longest and heaviest needle fascicles were associated with greater thinning intensities, foliar nutrient concentrations were not significantly different among thinning regimes. Total nutrients in the forest floor were inversely proportional to degree of thinning.

Shelterbelts

CHESNIN, LEON,* AND D. F. VAN HAVERBEKE.
1972.
Feedlot waste runoff, its influence on soil chemical properties and the survival of windbreak trees.
Agron. Abstr., Am. Soc. Agron. Annu. Meet. [Miami Beach, Fla., Oct.-Nov. 1972] Div. A-5, p. 178.
A combination of adverse soil chemical properties may result from flow of feedlot wastes through windbreaks. Trees in areas subjected to runoff flow from new feedlots may die rather quickly.

READ, RALPH A.
1972.
Plan before planting tree windbreaks.
Colo. Rancher Farmer 26(2):30, 34.
In addition to physical design and selection of species, planning must include purposes of the windbreak, maintenance, and correlation with other conservation practices.

READ, RALPH A.
1975.
Tree planting trends--as indicated by distribution of species in Great Plains States.
[21 p.] *In* Trees, food, energy. 27th Annu. Meet. Great Plains For. Comm. [Lincoln, Nebr., June 1975] Proc. Great Plains Agric. Counc. 76, n.p. [216 p.]
Summarizes 5-year planting trends, by coniferous trees, broad-leaved trees, and shrubs, for the 10 Prairie States.

SLABAUGH, PAUL E.
1974.
Renewed cultivation revitalizes sodbound shelterbelts.
J. Soil Water Conserv. 29:81-84.
Cultivation restored vigor of four multirow shelterbelts, 12 to 17 years old, in North Dakota. Sod removal after 11 years of neglect significantly increased height, diameter, and crown spread of Rocky Mountain juniper, boxelder, green ash, American elm, Siberian elm, and Siberian peashrub growing in medium- to coarse-textured soils.

VAN HAVERBEKE, DAVID F.
1973.
Renovating old deciduous windbreaks with conifers.
J. Soil Water Conserv. 28:65-68.
Eastern redcedar, ponderosa pine, and Austrian pine seedlings were evaluated for renovating old windbreaks. Control of competing vegetation during establishment and distance from residual windbreak trees--both directly related to availability of soil moisture--were key factors in successful establishment of planted seedlings.

VAN HAVERBEKE, DAVID F.
1974.
Use evergreens to renovate a windbreak.
Nebr. Coll. Agric.-Lincoln, Farm, Ranch Home Q. 21(1):12-14.
Decadent windbreaks can be renovated by replacing deteriorating rows of hardwoods with young evergreens. Control of competing vegetation and distance from remaining old windbreak trees -- both of which affect available soil moisture -- are key factors.

VAN HAVERBEKE, DAVID F., LEON CHESNIN,* AND DAVID R. MILLER.*
1976.
Feedlot waste runoff and mortality of windbreak trees.
J. Soil and Water Conserv. 31(1):14-17.
Runoff from confinement feedlots, flowing through windbreaks, killed mature trees. Feedlot runoff increased soil pH and conductivity and altered the exchangeable cation status but probably not enough to kill the trees. Heavy metals and organic substances leaching through the soil could also have been toxic.

Urban Forestry

COOK, DAVID I.,* AND DAVID F. VAN HAVERBEKE.
1972.
The potential value of trees, shrubs, and land form combinations for noise control.
Int. Shade Tree Conf., Midwest. Chapter [Chicago, Ill., Feb. 1972] 27:19-25.
Along highways, plant belts of trees and shrubs 65 to 100 feet wide, 50 to 80 feet from traffic. Take advantage of natural vegetation, ground forms, and tall grass or other soft ground cover.

COOK, DAVID I.,* AND DAVID F. VAN HAVERBEKE.
1972.
Trees and shrubs can curb noise, but with quite a few loud 'ifs'.
U. S. Dep. Agric. Yearb. 1972:28-30.
Knowledge of outdoor sound propagation, plus experience, is necessary in designing sound barriers with trees and shrubs.

COOK, DAVID I.,* AND DAVID F. VAN HAVERBEKE.
1972.
Trees, shrubs, and land-forms for noise control.
J. Soil Water Conserv. 27:259-261.
Tape-recorded and actual sounds of trucks, cars, and buses were used to determine the sound-attenuating properties of combinations of trees, shrubs, and land-forms. Recommendations for selection and optimum placement of tree structures are presented as well as tentative recommendations for forested land-form size and placement. (Paper presented at Soil Conservation Society of America's annual meeting, Portland, August 1972.)

COOK, DAVID I.,* AND DAVID F. VAN HAVERBEKE.
1972.
Trees, shrubs, and land-forms for noise control.
Soil Conserv. Soc. Am. [Portland, Ore., Aug. 1972] Proc. 27:151-154.
Tape-recorded and actual sounds of trucks, cars, and buses were used to determine the sound-attenuating properties of combinations of trees, shrubs, and land-forms. Recommendations for selection and optimum placement of tree structures are presented as well as tentative recommendations for forested land-form size and placement.

COOK, DAVID I.,* AND DAVID F. VAN HAVERBEKE.
1974.
Tree-covered land-forms for noise control.
Nebr. Agric. Exp. Stn. Res. Bull. 263, 47 p.
Combinations of trees, shrubs, and solid barriers effectively shield sensitive areas from noise. Sound reductions of 10 to 15 decibels (less than half as loud) are common for 12-ft high land-forms with wide belts of tall trees. Includes optimum heights for several applications, and instructions for establishing trees and shrubs on land-forms.

COOK, DAVID I.,* AND D. F. VAN HAVERBEKE.

1975.
Noise control.
p. 282-284, *In* Yearbook of Science and Technology, 1974. 460 p. McGraw-Hill, N.Y.
Wide belts of tall, dense trees can reduce traffic noise by 10 dB (cut noise in half). Combining trees and shrubs with solid landforms 10 feet high can reduce noise 15 dB. The barrier should be closer to the noise source than to the receiver.

SCHUBERT, GILBERT H.
1975.
Silviculturist's point of view on use of nonlocal trees.
USDA For. Serv. Gen. Tech. Rep. RM-11, 12 p.
Describes important factors that affect the health and vigor of forest trees introduced into communities and high density recreation areas. Seed origin, climatic and edaphic factors, and mycorrhizae are discussed first followed by insects, diseases, animal damage, and species selection.

VAN HAVERBEKE, DAVID F., AND DAVID I. COOK.*
1972.
Green mufflers.
Am. For. 78(11):28-31.
With quantitative data now available, significant noise abatement projects are currently being designed with trees, shrubs, and landforms. Dense masses of trees and shrubs are needed to reduce irritating noise to an acceptable level.

VAN HAVERBEKE, DAVID F., AND DAVID I. COOK.*
1974.
Studies in noise pollution reduction.
Am. Nurseryman 139(11):7,35-38; (12):11,71-75.
This two-part article describes how trees and shrubs reduce noise, and suggests plantings for reducing noise pollution. Suburban plantings can reduce noise levels 5 to 8 decibels, cutting loudness almost in half.

Survey, Inventory: See Assessment (Resource Inventories, Techniques) under RESOURCE ASSESSMENT AND ECONOMICS

Transportation Systems

WONG, PETER,* JORGE BARRIGA,* AND D. ROSS CARDER.
1975.
Methods for estimating traffic volumes and composition on National Forest roads.
p. 257-266. *In* Low-volume roads. NRC Transp. Res. Board Spec. Rep. 160, 396 p. Natl. Acad. Sci., Wash., D.C.
Concepts of traffic volume sampling and analysis are discussed in terms of probability theory and statistical inference. Modeling techniques were developed to estimate travel generated by recreation, logging, and administration under alternative management strategies.

Damage (Wildlife, Physical) and Protection

GOTTFRIED, GERALD J., AND JOHN R. JONES.
1975.
Logging damage to advance regeneration on an Arizona mixed conifer watershed.
USDA For. Serv. Res. Pap. RM-147, 20 p.
Damage to advance regeneration was studied after harvesting where special care was taken to avoid damage. With the selection method, 50 percent was destroyed, and in a one-cut overstory removal, 65 percent. The overstory removal area was left seriously understocked. Logging modifications are recommended to further reduce damage.

HEIDMANN, L. J.
1972.
An initial assessment of mammal damage in the forests of the Southwest.
USDA For. Serv. Res. Note RM-219, 7 p.
All size classes of trees are affected, but the problem is most serious in plantations and young trees. Mammals are a major factor in preventing the establishment of regeneration on one-half million acres of nonstocked forest land in the Southwest.

HEIDMANN, LEROY J.
1973.
Frost heaving in ponderosa pine.
West. For. Conserv. Assoc., Perm. Assoc. Comm. [San Jose, Calif., Dec. 1973] Proc. 1973:136-138.
Frost heaving results when soil water moves upward to a freezing zone where layers of pure ice are formed, lifting the soil. Several chemicals apparently reduce frost heaving without damaging seedlings. Plowing may also help by reducing soil bulk density, a directly related factor.

HEIDMANN, L. J., AND DAVID B. THORUD.*
1975.
Effect of bulk density on frost heaving of six soils in Arizona.
USDA For. Serv. Res. Note RM-293, 4 p.
For all soils and depths, frost heaving increased with bulk density. All soils had essentially the same water content when they started to freeze. At higher bulk densities, capillary flow is probably improved.

HEIDMANN, L. J.
1975.
Predicting frost heaving susceptibility of Arizona soils.
USDA For. Serv. Res. Note RM-295, 7 p.
This study used 15 variables in a stepwise regression analysis to develop an equation for predicting frost heaving susceptibility. Bulk density, sand content, and calcium accounted for 83 percent of the total variation in heaving.

HEIDMANN, L. J.
1976.
Frost heaving of tree seedlings: A literature review of causes and possible control.
USDA For. Serv. Gen. Tech. Rep. RM-21, 10 p.
Frost heaving is most serious among seedlings less than 1 year old. It appears to be a surface soil phenomenon. Soil water segregates and freezes into lenses of ice. Lens formation lifts the surface soil and the seedling. Upon thawing, the tree remains extruded on the soil surface.

NOBLE, DANIEL L., AND WAYNE D. SHEPPERD.
1973.
Grey-headed [Gray-headed] juncos important in first season mortality of Engelmann spruce.
J. For. 71:763-765.
Juncos clip attached seedcoats from newly germinated seedlings. In a 5-year study, these birds clipped 20 percent of the seedlings and were the second leading cause of first-season mortality in clearcut openings.

Experimental Techniques, Equipment

BARNHART, MICHAEL R.
1976.
A new compact pollinator.
USDA For. Serv. Res. Note RM-310, 2 p.
This simple, inexpensive pollinator is compact, waterproof, nonclogging, and requires only small quantities of pollen. It was used successfully for pollinating Scotch pine in a breeding program.

HEIDMANN, L. J.
1974.
An inexpensive chest for conducting frost-heaving experiments.
USDA For. Serv. Res. Note RM-269, 4 p.
A freezing chest constructed of plywood and styrofoam is described which can be built for approximately $60 (1974 costs)

NOBLE, DANIEL L., AND ROBERT R. ALEXANDER.
1975.
Rodent exclosures for the subalpine zone in the central Colorado Rockies.
USDA For. Serv. Res. Note RM-280, 4 p.
Two exclosures have effectively excluded rodents from an Engelmann spruce regeneration study. They have withstood deep snowpacks and required little maintenance during 6 years. Method of construction and recommendations for use are discussed.

RIETVELD, W. J.
1975.
An inexpensive truck-mounted ladder for inspecting conelet development and collecting cones.
USDA For. Serv. Res. Note RM-288, 4 p.
The versatile rig is stable, durable, quickly moved from tree to tree, and easily removed from the truck.

SHEPPERD, WAYNE D.
1973.
An instrument for measuring tree crown width.
USDA For. Serv. Res. Note RM-229, 3 p.
A small, handheld instrument for measuring tree crown widths has proved to be accurate, and has several advantages over existing equipment.

TRUJILLO, DAVID P.
1975.
Preparing aspen increment cores for ring counts.
J. For. 73(7):428.
To make counting of aspen rings easier, shave one side of fresh cores, ovendry, moisten shaved surface with penta in kerosene or mineral spirits, then ovendry again.

Multiple Use Relations

ALDON, EARL F., AND H. W. SPRINGFIELD.
1973.
The southwestern pinyon-juniper ecosystem: A bibliography.
USDA For. Serv. Gen. Tech. Rep. RM-4, 20 p.
Publications are categorized under six major headings: ecological investigations, silvics and management aspects, product utilization, range characteristics and wildlife values, water yield and sediment, and insects and diseases.

BERNTSEN, CARL M.
1975.
Management conflicts in lodgepole pine.
p. 503-515. *In* Manage. Lodgepole Pine Ecosyst. Symp. [Pullman, Wash., Oct. 1973] Proc., 2 vols. David M. Baumgartner, ed. Wash. State Univ., Pullman.
Clearcutting since 1950 has generated widespread concern as to possible adverse effects on the other forest land resources. This paper discusses management alternatives to resolve conflicts related to harvesting methods, scenic quality, wildlife, recreation, reforestation, and logging residues.

CLARY, WARREN P.
1975.
Present and future multiple use demands on the pinyon-juniper type.
p. 19-26. *In* The pinyon-juniper ecosystem: A symposium, May 1975. Utah State Univ., Utah Agric. Exp. Stn., Logan, Utah. 194 p.
Because of increasing pressures for livestock grazing, wildlife, and wood products, optimum management should result in a shifting mosaic of activities, with each site managed for the product or product mix for which it is best suited.

FFOLLIOTT, PETER F.,* AND WARREN P. CLARY.
1974.
Predicting herbage production from forest growth in Arizona ponderosa pine.
Prog. Agric. Ariz. 26(3):3-5.
Annual herbage production decreased as annual forest growth increased, in an unexpected linear relationship. Herbage prediction was improved by developing families of curves that added precipitation and elevation strata to timber growth.

FFOLLIOTT, PETER F.,* AND WARREN P. CLARY.
1975.
Differences in herbage-timber relationships on sedimentary and igneous soils in Arizona ponderosa pine stands.
Prog. Agric. Ariz. 27(3):6-7.
Significant differences in herbage-timber relationships on sedimentary and igneous soils indicate that herbage production predictions that do not account for soil differences may not be sufficiently accurate for use in land use planning or stratification.

FFOLLIOTT, PETER F.,* WARREN P. CLARY, AND MALCHUS B. BAKER, JR.
1976.
Characteristics of the forest floor on sandstone and alluvial soils in Arizona's ponderosa pine type.
USDA For. Serv. Res. Note RM-308, 4 p.
The forest floor affects the hydrologic cycle, herbage production, tree regeneration, and fire behavior. Forest floor depths and weights under ponderosa pine stands on soils developed from sedimentary parent materials were similar to those previously found on soils developed from volcanics.

MYERS, CLIFFORD A.
1974.
Multipurpose silviculture in ponderosa pine stands of the Montane Zone of central Colorado.
USDA For. Serv. Res. Pap. RM-132, 15 p.
Presents silvicultural prescriptions for ponderosa pine in an area where several uses and products of the forest are important, but scenic and recreation values predominate.

SEVERSON, KIETH E., AND CHARLES E. BOLDT.
1976.
Quality and quantity of forage and wood as related to tree stocking levels in Black Hills ponderosa pine.
Soc. Range Manage. [Omaha, Nebr., Feb. 1976] Abstr. of Pap. 29:37.
Diameter growth of trees was most rapid at lower stocking levels. Stocking level did not affect wood quality, however, or forage quality of a shrub and a grass, but a forb had higher digestible dry matter under unthinned saplings.

FOREST PRODUCTS

*Private, State or Federal cooperator

Harvesting (Product-Related)

SAMPSON, GEORGE R., HAROLD E. WORTH, AND DENNIS M. DONNELLY.
1974.
Demonstration test of inwoods pulp chip production in the Four Corners region.
USDA For. Serv. Res. Pap. RM-125, 19 p.
Pulpwood and noncommercial material were chipped by a portable debarker-chipper in two test areas: a ponderosa pine site in Arizona, and a spruce-fir site in Colorado. Chips from both areas were delivered to a pulpmill at Snowflake, Arizona. Feasibility analysis included physical, economic, and environmental evaluation.

Wood Structure, Species Characteristics

BARGER, ROLAND L., AND PETER F. FFOLLIOTT.
1972.
Physical characteristics and utilization of major woodland tree species in Arizona.
USDA For. Serv. Res. Pap. RM-83, 80 p.
Woodland species in the Southwest, primarily Utah and alligator juniper, pinyon pine, and Gambel oak, represent a vast resource potentially useful for veneer, particleboards, charcoal, pulp, and chemical extractives.

BARGER, ROLAND L., AND PETER F. FFOLLIOTT.
1976.
Factors affecting occurrence of compression wood in individual ponderosa pine trees.
Wood Sci. 8(3):201-208.
Lean, either by itself or in combination with other visual tree characteristics, was an unreliable predictor of compression wood in northern Arizona. Release through thinning or partial cutting may substantially increase incidence of compression wood in trees that respond with increased growth rates.

BOLDT, C. E., AND C. (D.) MARKSTROM.
1972.
Rapid growth and wood quality in Black Hills ponderosa pine.
For. Prod. Res. Soc. [Dallas, Tex., June 1972] Abstr. 26:6.
Thinning to hasten growth increased ring width, but specific gravity, percent late wood, and percent extractives were not significantly changed.

MARKSTROM, DONALD C., AND ROBERT A. HANN.*
1972.
Seasonal variation in wood permeability and stem moisture content of three Rocky Mountain softwoods.
USDA For. Serv. Res. Note RM-212, 7 p.
Time of year does not affect wood permeability but does affect water content of Engelmann spruce, lodgepole pine , and Douglas-fir trees, especially the sapwood. The water contents were highest during winter.

MARKSTROM, DONALD C., AND VERN P. YERKES.
1972.
Specific gravity variation with height in Black Hills ponderosa pine.
USDA For. Serv. Res. Note RM-213, 4 p.
Average specific gravity decreased with increasing height up the merchantable stem. The mature trees with d.b.h. 11.0 inches or less had the highest specific gravity at all stem levels. The table presented provides a means of predicting specific gravity at different relative heights of the merchantable stem.

Timber Manufacturing

ERICKSON, BERNARD J., AND DONALD C. MARKSTROM.
1972.
Predicting softwood cutting yield by computer.
USDA For. Serv. Res. Pap. RM-98, 15 p.
A computer program, written in FORTRAN, predicts the maximum yield of cutting for a softwood cut-up and edge- and end-gluing operation. The program calculates cutting recovery (given cutting width and length constraints and defect locations on the board), and locates ripping saw kerfs.

YERKES, VERN P., AND R. O. WOODFIN, JR.*
1972.
Veneer recovery from Black Hills ponderosa pine.
USDA For. Serv. Res. Pap. RM-82, 23 p.
Veneer recovered from a selected sample of 144 sawtimber trees was sufficient in both volume and grades to allow production of at least 3/8-inch C-D plywood.

YERKES, VERN P.
1974.
Black Hills ponderosa pine timber: Poles, saw logs, veneer logs, stud logs, or pulp.
USDA For. Serv. Res. Pap. RM-118, 12 p.
A multiproduct analysis indicates gross volumes per acre of 4,944 fbm of saw logs, 4,680 fbm of veneer logs, or 3,052 fbm of stud logs if inventoried for these products individually. If inventoried simultaneously for highest multiproduct potentials, however, gross allocated volumes were 881, 3,165, and 143 fbm per acre.

Wood Protection

MARKSTROM, DONALD C., AND DAVID H. CLARK.
1975.
Service life of treated and untreated Black Hills ponderosa pine fenceposts: A progress report.
USDA For. Serv. Res. Note RM-303, 4 p.
Ponderosa pine fenceposts treated with preservatives are performing favorably after field exposures of 13 to 14 years. Test sites are in the Northern Great Plains--one in the semiarid western portion near Scenic, South Dakota; the other in the more humid eastern portion near Brookings.

Adhesives and Bonded Products

MUELLER, LINCOLN A., ROLAND L. BARGER, ARTHUR BOURKE,* AND DONALD C. MARKSTROM.
1972.
Roll laminating fiber overlays on low-grade ponderosa pine lumber.
USDA For. Serv. Res. Pap. RM-97, 28 p.
In pilot plant tests, lumber was satisfactorily overlaid at speeds up to 180 fpm. at a cost, exclusive of substrate, of 4 to 5 cents per square foot. Commercial feasibility is restricted by need for an effective automated defect repair system, and lack of assured markets.

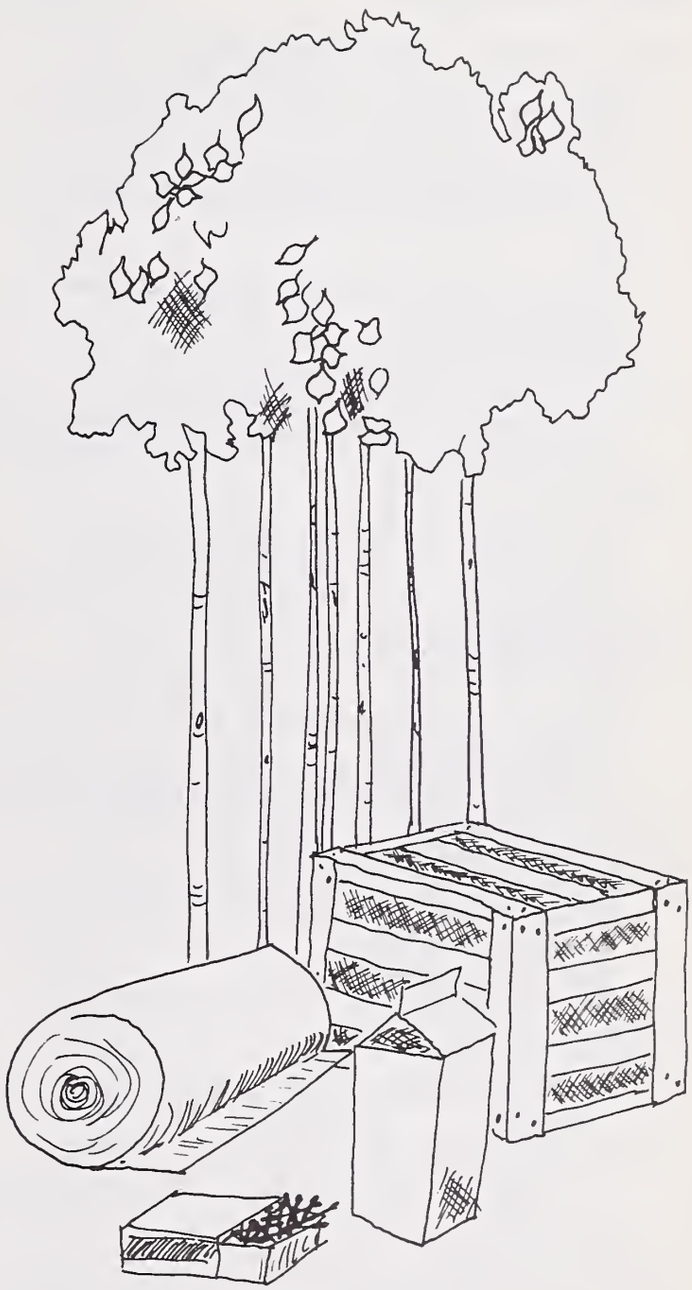
Market Analyses, Development, Statistics

LEWIS, GORDON D.
1973.
The wood pole market: recent trends and outlook. ***In*** **The changing polescape.**
Wood Pole Inst. [Fort Collins, Colo., July 1971] Proc. 5:10-19.
The number of wood poles treated each year has been declining since 1966. The increasing trend toward underground utility systems is likely a major factor. Esthetic and other advantages of pole-frame construction could greatly enlarge alternative markets, however.

WORTH, HAROLD E.
1973.
Prospects for new particleboard production in the Rocky Mountains.
p. 58-72. ***In*** **'MULE'--Multi-product utilization, labor, and equipment. Rocky Mt. For. Ind. Conf. [Rapid City, S.D., Apr. 1973] Proc. 72 p.**
Prospects are favorable due to increasing national demand, plentiful raw materials, and favorable locations with respect to major markets. New producers should make a careful choice between product alternatives and production systems, since the $6 to $10 million capital investment required makes it difficult to shift products.

Residue Use

SABEY, B. R.,* N. N. AGBIM,* AND D. C. MARKSTROM.
1975.
Land application of sewage sludge: III. Nitrate accumulation and wheat growth resulting from addition of sewage sludge and wood wastes to soils.
J. Environ. Qual. 4(3):388-393.
Mixtures of anaerobically digested sewage sludge and wood-bark residues increased wheat growth in greenhouse studies. Wood and bark partially immobilized nitrate ions, and slowed leaching. Wheat growth was optimum when wood-bark residue was not more than 25 percent of the mixture with sludge.



RANGE AND WILDLIFE HABITAT MANAGEMENT

*Private, State or Federal cooperator

Plant Taxonomy

CRUM, HOWARD,* AND F. J. HERMANN.
1972.
***Sphagnum magellanicum* new to the West Indies.**
Bryologist 75:359-360.
Sphagnum magellanicum is recorded from Jamaica and the Dominican Republic as first records for the West Indies.

FEDDEMA, CHARLES.
1972.
***Sclerocarpus uniserialis* (Compositae) in Texas and Mexico.**
Phytologia 23:201-209.
The species has three varieties. Variety *uniserialis* occurs in Texas, a newly described var. *rubridiscus* occurs in southwest Mexico, and var. *frutescens* ranges from eastern Mexico to Guatemala. Hybrids of the last two occur in southern Mexico.

HERMANN, FREDERICK J.
1972.
A new variety of *Carex bicknellii* from Arkansas.
Sida 5(1):49.
Describes and discusses a new variety that has long been confused with *Carex brittoniana*.

HERMANN, FREDERICK J.
1973.
Additions to the bryophyte flora of Alaska.
Bryologist 76:442-446.
Nine hepatic and 32 moss taxa are added to the known flora of Alaska. Three dubious earlier reports are verified, and new stations included for two rare species.

HERMANN, FREDERICK J.
1973.
Additions to the bryophyte flora of Mt. McKinley National Park, Alaska.
Bryologist 76:563-565.
Six hepatic and 27 moss taxa are added to the known flora.

HERMANN, FREDERICK J.
1974.
Manual of the genus *Carex* in Mexico and Central America.
U.S. Dep. Agric., Agric. Handb. 467, 219 p.
An original treatment of the 102 taxa of the genus *Carex* (family Cyperaceae) now known from Mexico and Central America. Detailed descriptions, keys for identification, and illustrations for each species are included. (Available from Superintendent of Documents, Stock No. GPO 0100-03259, $2.85, paper cover.)

HERMANN, FREDERICK J., AND HAROLD ROBINSON.*
1974.
Additions to the bryophyte flora of Bolivia.
Bryologist 66(4):643-645.
Based upon the senior author's 1972 collections, 12 hepatics and 14 mosses are added to the known flora of Bolivia.

HERMANN, FREDERICK H.
1975.
Manual of the rushes (*Juncus* spp.) of the Rocky Mountains and Colorado Basin.
USDA For. Serv. Gen. Tech. Rep. RM-18, 107 p.
A taxonomic treatment of the 51 taxa of the critical genus *Juncus* known from the Rocky Mountains and Colorado Basin. Detailed descriptions, synonymy, key for identification, illustrations, habitats, geographic distribution, and data on forage value are included.

LAWTON, ELVA,* AND F. J. HERMANN.
1973.
A new *Orthotrichum* from northern California.
Bryologist 76:437-439.
Orthotrichum epapillosum Lawt. and Herm. is described as a new species from California. It differs from other species with immersed stomata, in its epapillose leaf cells. The calyptra is without hairs and the apices of mature leaves are broad and rounded.

NICKERSON, MONA F., GLEN E. BRINK, AND CHARLES FEDDEMA.
1976.
Principal range plants of the central and southern Rocky Mountains: Names and symbols.
USDA For. Serv. Gen. Tech. Rep. RM-20, 121 p.
Provides scientific names, useful synonyms, common names (where available), and standard symbols for use in field records. Scientific names are generally those from manuals specified as authoritative by Forest Service policy. The list has been prepared by use of data processing equipment.

Plant Physiology, Morphology, Genetics

ALCORN, STANLEY M.,* AND S. CLARK MARTIN.
1974.
***Cereus giganteus* Engelm. Saguaro.**
p. 313-314. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

ALEXANDER, ROBERT R., KENT JORGENSEN,* AND A. P. PLUMMER.*
1974.
***Cowania mexicana* var. *stansburiana* (Torr.) Jepsen. Cliffrose.**
p. 353-355. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

ALEXANDER, ROBERT R., AND FLOYD W. POND.
1974.
***Yucca* (L.). Yucca.**
p. 857-858. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

CABLE, DWIGHT R.
1974.

Early development of range grass inflorescence.
Prog. Agric. Ariz. 26(1):8-9.

The seed-producing process begins with microscopic changes in the growing point at the upper end of the shoot. A single bite by a hungry cow at this stage can not only destroy the developing seed head, but also a foot or more of developing shoot and leaves.

CLARY, WARREN P.
1975.
Ecotypic adaptation in *Sitanion hystrix*.
Ecology 56(6):1407-1415.

The populations studied adapted to different climatic conditions primarily through variations in timing of phenological development and in rate of growth. No differences in water use efficiency were found. The primary factors which influence morphological and production characteristics may be more numerous or complex than those which influence phenology.

DIETZ, DONALD R., AND PAUL E. SLABAUGH.
1974.
***Caragana arborescens* Lam. Siberian peashrub.**
p. 262-264. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

EVANS, KEITH E.
1974.
***Symphoricarpos* Duham. Snowberry.**
p. 787-790. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

KNIPE, O. D., AND H. W. SPRINGFIELD.
1972.
Germinable alkali sacaton seed content of soils in the Rio Puerco Basin, west central New Mexico.
Ecology 53:965-968.

Most seeds are blown across barren sites interspersed through native stands. The few seeds trapped in microsites in the soil apparently are either removed by wind, water, animals, or insects, or are killed due to unfavorable moisture-temperature conditions.

KNIPE, O. D.
1973.
Western wheatgrass germination as related to temperature, light, and moisture stress.
J. Range Manage. 26:68-69.

Germination of western wheatgrass was best when seeds were held for 16 hours at temperatures between 55 F. and 75 F. and 8 hours at temperatures between 75 F. and 90 F. daily. Germination was independent of light, but was severely reduced by moisture stresses above 1.0 atmospheres.

KNIPE, O.D.
1974.
Effect of heat treatment on germination of alkali sacaton.
USDA For. Serv. Res. Note RM-268, 3 p.

Dry seeds withstood 225 degrees F without injury. Large seeds which had imbibed for 8 hours and small seeds which had imbibed for 4 hours were injured by heating at 160 degrees F for 1 hour. Both large and small seeds were injured by 150 degrees F after 24 hours' imbibition.

MARTIN, S. CLARK.
1974.
***Larrea tridentata* Vail. Creosotebush.**
p. 486-487. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

MARTIN, S. CLARK, AND ROBERT R. ALEXANDER.
1974.
***Prosopis juliflora* (Swartz) DC. Mesquite.**
p. 656-657. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

REYNOLDS, HUDSON G., AND ROBERT R. ALEXANDER.
1974.
***Garrya* Dougl. Silktassel.**
p. 420-421. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

REYNOLDS, H. G., AND ROBERT R. ALEXANDER.
1974.
***Tamarix pentandra* Pall. Five-stamen tamarisk.**
p. 794-795. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

SEVERSON, KIETH E., AND E. CHESTER GARRETT.
1974.
Growth characteristics of bearberry in the Black Hills.
USDA For. Serv. Res. Note 254, 3 p.

Growth of bearberry (*Arctostaphylos uva-ursi*) varied widely between plants and between sites. Most annual growth (66 percent) occurred during June when moisture and temperature conditions were apparently optimum. Annual growth can readily be recognized by the presence of nodes and by color changes.

SLABAUGH, PAUL E.
1974.
***Cotoneaster* B. Ehrh. Cotoneaster.**
p. 349-352. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

SLABAUGH, PAUL E.
1974.
***Hippophae rhamoides* [*rhamnoides*] L. Common seabuckthorn.**
p. 446-447. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.

Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

SMITH, DWIGHT R., AND LOUIS N. BASS.*
1973.
Germinability of true mountainmahogany achenes as influenced by soil and other environmental factors.
Proc. Assoc. Off. Seed Anal. 63:126-134.

Differences in percent germination, percent filled, and weights of true mountainmahogany achenes on four mountain soils were highly significant. Germination, fill, and weight were greater from northwest aspects than from southwest. Achenes with highest germination were from plants on northwest aspects in the least fertile soil, which had the lowest population of mountainmahogany.

SPRINGFIELD, H. W.
1972.
Optimum temperatures for germination of winterfat.
J. Range Manage. 25:69-70.

Optimum temperatures for germination were 50 to 80 F. Germination was practically complete within 5 days at 59 F.

SPRINGFIELD, H. W.
1972.
Winterfat seeds undergo after-ripening.
J. Range Manage. 25:479-480.
Seeds were collected in 4 consecutive years in New Mexico. After-ripening was completed within 10 weeks for all except one collection, which required 25 weeks.

SPRINGFIELD, H. W.
1973.
Winterfat fruits and seeds retain high viability 3 years in cold storage.
USDA For. Serv. Res. Note RM-233, 3 p.
Fruits and seeds of winterfat (*Eurotia lanata*) were stored 3 years in sealed and unsealed containers under four temperatures. Seed stored in sealed containers under refrigeration or subzero temperatures retained 93 to 99 percent viability. By contrast, seed stored in unsealed containers under room conditions retained only 46 percent viability, and under outside shed conditions, only 3 percent viability. Cold storage in sealed containers is recommended.

SPRINGFIELD, H. W.
1973.
Cliffrose and mountainmahogany seeds retain viability 6 years in cold storage.
USDA For. Serv. Res. Note RM-236, 2 p.
Viability was highest for seeds stored at -5 to -10 F. or 36 to 44 F.

SPRINGFIELD, H. W.
1973.
Larger seeds of winterfat germinate better.
J. Range Manage. 26:153-154.
Seeds of winterfat (*Eurotia lanata*) were separated into three size classes and germinated under four temperature regimes. Large- and medium-size seeds germinated better and faster.

SPRINGFIELD, H. W.
1974.
Winterfat seeds viable after 8 years refrigerated storage.
J. Range Manage. 27:78.
Five collections of winterfat seeds from New Mexico were stored in cans under refrigeration and ordinary temperatures. After 8 years, viability ranged from 51 to 80 percent for the refrigerated seeds, but practically no seeds remained viable under the warmer storage temperatures.

SPRINGFIELD, H. W.
1974.
***Eurotia lanata* (Pursh) Moq. Winterfat.**
p. 398-400. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

THILENIUS, JOHN F., KEITH E. EVANS, AND E. CHESTER GARRETT.
1974.
***Shepherdia* Nutt. Buffaloberry.**
p. 771-773. *In* Seeds of woody plants in the United States. U.S. Dep. Agric., Agric. Handb. 450, 883 p.
Briefly describes general growth, flowering, and fruiting characteristics of the species and summarizes available information on seed handling, testing, and nursery practices.

WILLIAMS, S. E.,* A. G. WOLLUM II,* AND EARL F. ALDON.
1974.
Growth of *Atriplex canescens* (Pursh) Nutt. improved by formation of vesicular-arbuscular mycorrhizae.
Soil Sci. Soc. Am. Proc. 38:962-965.
Mycorrhizal fourwing saltbush grown in nonsterile soil were heavier and accumulated more phosphorus than nonmycorrhizal plants grown in sterile soil. Inoculation of fourwing saltbush with a known endomycorrhizal fungus, *Endogone mosseae* stimulated plant growth.

WILLIAMS, STEPHEN E., AND EARL F. ALDON.
1976.
Endomycorrhizal (vesicular arbuscular) associations of some arid zone shrubs.
Southwest. Nat. 20(4):437-444.
Vesicular arbuscular endomycorrhizae were observed in association with several shrubs important for livestock and wildlife. Root fungi were stained using acid fuchsin in chloral hydrate solution. Fungal spores were extracted from soil by centrifugal flotation or sieving-decanting methods.

Herbage Growth, Values

CABLE, DWIGHT R., AND S. CLARK MARTIN.
1975.
Vegetation responses to grazing, rainfall, site condition, and mesquite control on semidesert range.
USDA For. Serv. Res. Pap. RM-149, 24 p.
Over a 10-yr period, mesquite control increased perennial grass production 52 percent. Perennial grass production was highly dependent on both the previous and current summer's rainfall, indicating 2 yrs are required for recovery from a 1-yr drought. Stocking rates could be estimated as accurately from rainfall as from grass production.

CABLE, DWIGHT R.
1975.
Influence of precipitation on perennial grass production in the semidesert Southwest.
Ecology 56(4):981-986.
Production depended primarily on current summer and previous summer rainfall. Previous summer rainfall was an interaction effect. The best overall relationship involved current August rainfall, previous June-through-September rainfall, and their interaction product. Winter precipitation had no consistent effect on perennial grass production the following summer.

CLARY, WARREN P., AND DOUGLAS C. MORRISON.*
1973.
Large alligator junipers benefit early-spring forage.
J. Range Manage. 26:70-71.
Production of early-spring grasses in central Arizona was 4 to 5 times higher under crowns of large alligator junipers than away from trees. Because virtually all green forage grazed by animals at this time of year grew under these trees, they should be protected during control operations.

CLARY, WARREN P.
1974.
Response of herbaceous vegetation to felling of alligator juniper.
J. Range Manage. 27:387-389.
Felling a 13 percent cover of alligator juniper in northcentral Arizona increased total herbage production 38 percent and forage plant production 45 percent. These increases were highly variable. There was little or no apparent response in 3 of 7 postfelling years.

CLARY, WARREN P., AND HENRY A. PEARSON.*
1976.
Herbage changes following thinning and grazing of a southwestern ponderosa pine stand.
Soc. Range Manage. [Omaha, Nebr., Feb. 1976] Abstr. of Pap. 29:37.
After pine stands are thinned, herbage yields usually increase rapidly to levels considerably higher than under unthinned stands of similar basal area, then slowly decline. Grazing accelerates

the decline. Plant composition (seeded versus native) is not necessarily an important factor.

MARTIN, S. CLARK.
1972.
Some effects of continuous grazing on forage production.
Ariz. Cattlelog 28(10):17-18, 23-25.
Many semidesert ranges need systems of grazing that will give perennial grasses a chance to recover on closely grazed areas. On the Santa Rita Experimental Range, resting the range March to October 2 years out of 3 has been more effective than closing waters during the summer growing season.

THILENIUS, JOHN F.
1975.
Plant production of three high-elevation ecosystems. p. 60-75. *In* The Medicine Bow ecology project, final report, February 28, 1975. D. H. Knight, coord., Univ. Wyo., Laramie, for Div. Atmos. Water Resour. Manage., Bur. Reclam., U.S. Dep. Int., Denver, Colo.
Provides quantitative information on above- and belowground biomass (live vegetation, standing dead vegetation, litter, and root biomass) of two alpine tundra and one subalpine meadow ecosystem in the Medicine Bow Mountains. Data are presented by biweekly intervals for two growing seasons. (Entire report available from NTIS, 397 p., $3.)

THILENIUS, JOHN F., AND GARY R. BROWN.
1976.
Effect of 2,4-D on digestibility and production of subalpine herbage.
J. Range Manage. 29(1):63-65.
Treating forb-dominated subalpine cattle range in the Bighorn Mountains, Wyoming, did not change digestibility coefficients of grasses or surviving forbs. Forbs and grasses were equally digestible throughout the growing season. Production of total and digestible dry matter was not increased.

Measurement Methods and Equipment: See also Assessment (Resource Inventories, Techniques) under RESOURCE ASSESSMENT AND ECONOMICS

CARPENTER, L. H.,* O. C. WALLMO, AND M. J. MORRIS.
1973.
Effect of woody stems on estimating herbage weights with a capacitance meter.
J. Range Manage. 26:151-152.
Herbage weight can be estimated more accurately by ignoring the contribution of woody stems to capacitance readings. These stems should be clipped and measured only if an estimate of total biomass is desired.

CURRIE, PAT O., M. J. MORRIS, AND D. L. NEAL.*
1973.
Uses and capabilities of electronic capacitance instruments for estimating standing herbage. Part 2. Sown ranges.
J. Brit. Grassl. Soc. 28:155-160.
A meter effectively estimated herbage yields of sown ranges in Arizona and Colorado. Methods of placing the meter in relation to drill rows, cutting procedures, and evaluation of organic matter are described which avoid biased estimates and improve regressions. Part 1 describes evolution of the meter.

FRANCIS, RICHARD E., RICHARD S. DRISCOLL, AND JACK N. REPPERT.
1972.
Loop-frequency as related to plant cover, herbage production, and plant density.
USDA For. Serv. Res. Pap. RM-94, 8 p.
Frequency measured by the 3/4-inch loop technique was compared to estimates of plant basal cover, foliar cover, herbage production, and density. The relationship between loop-frequency and the other parameters were rarely significant or consistent as determined by regression and correlation. Loop-frequency unpredictably overrated foliar and basal plant cover on the basis of ratio estimates, a relative measure of bias. Therefore, frequency estimated by the 3/4-inch loop technique can be equated only to itself and not used to make inferences about other plant community parameters.

MORRIS, MEREDITH J.
1973.
Estimating understory plant cover with rated microplots.
USDA Forest Serv. Res. Pap. RM-104, 12 p.
Trained range personnel rate small plots similarly in respect to area occupied by aerial and basal plant cover. Equal area rectangles and circles ranging from 1/8 square inch to 8 square inches were used. All are well suited for rating plant cover, although smaller sizes were slightly more precise.

MORRIS, MEREDITH J., KENDALL L. JOHNSON, AND DONALD L. NEAL.*
1976.
Sampling shrub ranges with an electronic capacitance instrument.
J. Range Manage. 29(1):78-81.
Electronic capacitance meters can provide a rapid, accurate, and nondestructive means of estimating total aboveground and herbaceous dry matter yields in low-shrub lands. A double sampling technique is necessary to obtain reliable yield estimates, maximum cost reduction, and the most efficient use of the meters.

NEAL, D. L.,* AND J. L. NEAL.*
1973.
Uses and capabilities of electronic capacitance instruments for estimating standing herbage. Part 1. History and development.
J. Brit. Grassl. Soc. 28:81-89.
Problems with short or dry vegetation, nonhomogeneous distribution of vegetation, nonhomogeneous phenology, and electronic circuit instability have been greatly reduced by improvements in instrumentation. Instruments have proved their value under a wide variety of range conditions.

NEAL, DONALD L.,* PAT O. CURRIE, AND MEREDITH J. MORRIS.
1976.
Sampling herbaceous native vegetation with an electronic capacitance instrument.
J. Range Manage. 29(1):74-77.
Yields were estimated on vegetation types varying from a low-elevation annual type to a high-elevation alpine type. Phenology, dead organic matter, plant stature, composition, and meter placement within the vegetation affected efficiency of yield estimates. Double sampling techniques are necessary.

PATTON, DAVID R.
1974.
Estimating food consumption from twigs clipped by the Abert squirrel.
USDA For. Serv. Res. Note RM-272, 3 p.
Abert squirrels consume the inner bark of ponderosa pine twigs. Mean length, diameter, and dry weight of peeled twigs was 88 mm, 5.9 mm, and 1.3 g, respectively. A table gives dry weight of inner bark from dry weight of a peeled twig.

PATTON, DAVID R.
1975.
A diversity index for quantifying habitat 'edge.' Wildl. Soc. Bull. 3(4):171-173.
The Diversity Index measures total perimeter plus any linear edge within an area, compared to the perimeter of a circle. Number of vegetation types and size of area make the index more meaningful. A DI of 1.69(4)1,000 would indicate a 1.69 index with four types on 1,000 acres.

REPPERT, JACK N., AND RICHARD E. FRANCIS.
1973.
Interpretation of trend in range condition from 3-step data.
USDA For. Serv. Res. Pap. RM-103, 15 p.
A 5-phase procedure uses 3-step data to identify trends and assign cause: (1) strict fieldwork, (2) determining tentative trend, (3) office tests and photointerpretation, (4) relating change characteristics to trends judged in the field, and (5) assigning probable trend causes.

SPRINGFIELD, H. W.
1974.
Using a grid to estimate production and utilization of shrubs.
J. Range Manage. 27:76-78.
Production of fourwing saltbushes was estimated from photographs against a 1-inch grid. All squares partially or completely obscured were counted. Utilization of several shrub species was estimated from photos taken before and after browsing by deer.

Livestock Management, Grazing Systems, Nutrition

CABLE, DWIGHT R.
1975.
Range management in the chaparral type and its ecological basis: The status of our knowledge.
USDA For. Serv. Res. Pap. RM-155, 30 p.
Chaparral in Arizona is used far below its potential. Conversions to grass can greatly increase water and grass production, and improve wildlife habitat. Management options include conversion to grass, maintaining shrubs in a sprout stage, changing shrub composition, reseeding, and using goats to harvest shrub forage.

CLARY, WARREN P.
1975.
Range management and its ecological basis in the ponderosa pine type of Arizona: The status of our knowledge.
USDA For. Serv. Res. Pap. RM-158, 35 p.
Summarizes and evaluates available information about Arizona ponderosa pine-bunchgrass ranges. It covers physical-biological characteristics, factors influencing livestock production, grazing allotment conditions, and economics, and correlates grazing with other uses. Several knowledge gaps are also identified.

CURRIE, PAT O.
1975.
Plant response and livestock weight changes on big bluegrass range grazed during late fall, winter, and early spring.
J. Range Manage. 28(5):340-343.
Yearling heifers gained weight during late fall with or without protein supplement, but less than animals that grazed native range and received protein. During winter and early spring, animals lost weight. Grazing was not detrimental to Sherman big bluegrass during any period from late fall to early spring.

CURRIE, PAT O.
1975.
Grazing management of ponderosa pine-bunchgrass ranges of the central Rocky Mountains: The status of our knowledge.
USDA For. Serv. Res. Pap. RM-159, 24 p.
Pine-bunchgrass ranges are important livestock-producing areas in the central Rocky Mountains. Livestock-management techniques are well developed and soundly based on research within the type. There is a need, however, to understand the interrelationships of other land uses, particularly as they relate to human population pressures.

GALT, H. D.,* BRENT THEURER,* AND S. CLARK MARTIN.
1972.
Botanical composition of cattle diets on velvet mesquite-fair and nonmesquite-good desert grassland. Soc. Range Manage. [Wash., D.C., Feb. 1972] Abstr. of Pap. 25:12.
Animal diets were only slightly different between the two pastures; Arizona cottontop predominated in both. Protein content of fistula samples was consistently higher than that of the major available grasses. Excess protein was attributed to higher protein shrubs and parts of grasses.

MARTIN, S. CLARK, AND DONALD E. WARD.
1973.
Salt and meal-salt help distribute cattle use on semidesert range.
J. Range Manage. 26:94-97.
Placing salt or meal-salt 1 to 2-1/2 miles from water increased utilization of perennial grasses where use was usually light, but did not decrease use near water in the heavy use zone. No cattle injury due to either inadequate or excessive salt intake was observed.

MARTIN, S. CLARK.
1973.
Responses of semidesert grasses to seasonal rest.
J. Range Manage. 26:165-168.
Perennial grasses in southern Arizona increased more in 8 years under spring-summer (March-October) rest 2 years out of 3 than under continuous yearlong grazing or any of 13 other rest schedules.

MARTIN, S. CLARK.
1973.
A grazing system for semidesert ranges based on responses of grasses to seasonal rest.
Soc. Range Manage. [Boise, Idaho, Feb. 1973] Abstr. of Pap. 26:21.
Only one of three pastures is grazed at a time, and each gets (1) spring-summer rest 2 years out of 3, (2) winter grazing only between the two consecutive spring-summer rest periods, and (3) a full year of rest before each spring-summer grazing.

MARTIN, S. CLARK, AND HUDSON G. REYNOLDS.
1973.
The Santa Rita Experimental Range: Your facility for research on semidesert ecosystems.
J. Ariz. Acad. Sci. 8:56-67.
Describes the Range and its history, and gives the working ecologist an idea of the variety and scope of information available from 70 years of research on the impacts of grazing on the ecosystem, and relationships between flora, fauna, climate, and soils.

MARTIN, S. CLARK, AND DWIGHT R. CABLE.
1975.
Highlights of research on the Santa Rita Experimental Range.

p. 51-57. *In* Arid Shrublands. Proc. Third Workshop of U.S./Aust. Rangelands Panel, Tucson, Ariz., Mar. 26-Apr. 5, 1973. 148 p.

The Santa Rita, established in 1903, is the oldest research area of the U.S. Forest Service. Research on the interrelationships of organisms, attributes, and processes in semidesert ecosystems is intended to help landowners and administrators achieve land use goals to meet changing needs and demands of society.

MARTIN, S. CLARK.

1975.

Stocking strategies and net cattle sales on semidesert range.

USDA For. Serv. Res. Pap. RM-146, 10 p.

Simulating impacts of variable forage yields on income over a 29-year period indicates the cow herd should be maximized, cows should be bred to calve at age 2 and culled at age 8, and constant stocking at 90 percent of average proper stocking balances income against risk of overstocking.

MARTIN, S. CLARK.

1975.

Ecology and management of southwestern semidesert grass-shrub ranges: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-156, 39 p.

Vegetation on much semidesert range has shifted from grassland to brush since livestock ranching began. Shrub control, reseeding, and improved grazing management can reverse the trend. Grazing will continue to be a major use for semidesert range despite high land prices and increased recreational activity.

PAULSEN, HAROLD A., JR.

1975.

Range management in the central and southern Rocky Mountains: A summary of the status of our knowledge by range ecosystems.

USDA For. Serv. Res. Pap. RM-154, 34 p.

Summarizes a series of comprehensive reports on the seven recognized ecosystems: Semidesert grass-shrub, southwestern chaparral, pinyon-juniper, central Rockies ponderosa pine-bunchgrass, Arizona ponderosa pine-bunnchgrass, mountain grassland, and alpine. Includes what is known, what can be recommended, and what additional information is needed for each ecosystem.

PEARSON, HENRY A.

1972.

Estimating cattle gains from consumption of digestible forage on ponderosa pine range.

J. Range Manage. 25:18-20.

In vitro digestibility measurements reduce the variability in estimating cattle gains from forage intake measurements. The daily digestible forage intake requirements of range cattle appear similar to the requirements of cattle in feedlots.

PEARSON, HENRY A.

1973.

Calculating grazing intensity for maximum profit on ponderosa pine range in northern Arizona.

J. Range Manage. 26:277-278.

The profit formula is based on forage production, digestibility and utilization, animal weight and daily gain, costs per animal day, and beef prices. Rangeland producing 500 to 1,000 pounds of forage per acre would produce maximum profit with moderate utilization.

SPRINGFIELD, H. W.

1976.

Characteristics and management of southwestern pinyon-juniper ranges: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-160, 32 p.

The major problem in the pinyon-juniper type is widespread deterioration of the range resources due to overgrazing and increases in tree density. General guidelines are available for judging the condition and grazing management of pinyon-juniper ranges, as well as for deciding where and how to control trees.

THILENIUS, JOHN F.

1975.

Alpine range management in the western United States--principles, practices, and problems: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-157, 32 p.

Reviews the present knowledge on the ecology and management of the alpine zone in western North America; describes the characteristics of the alpine; covers the unique ecology of the high-elevation, cold-dominated, alpine ecosystems; and discusses their management, with emphasis on the range resource and its relationship with other uses.

TURNER, GEORGE T., AND HAROLD A. PAULSEN, JR.

1976.

Management of mountain grasslands in the central Rockies: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-161, 24 p.

Knowledge is generally adequate for proper grazing management of these grasslands, but management and improvement costs tend to be relatively high because of their remoteness. Suggested improvements to increase range usability, improve forage production, and control livestock must be coordinated with water and timber production, and wildlife and recreation needs.

WARD, DONALD E.

1975.

Seasonal weight changes of cattle on semidesert grass-shrub ranges.

J. Range Manage. 28:97-99.

Average cow weights, on semidesert grass-shrub ranges in southern Arizona, increased slightly following spring greenup, but major weight gains began with summer forage and continued into November. Major weight losses were at calving time in December and January.

Range Improvement

ALDON, EARL F.

1972.

Critical soil moisture levels for field planting fourwing saltbush.

J. Range Manage. 25:311-312.

Survival was at least 80 percent when alluvial field sites had soil moisture levels of at least 14 percent by weight or were at tensions between 1/3 and 2 atmospheres.

ALDON, EARL F., AND GEORGE GARCIA.

1972.

Vegetation changes as a result of soil ripping on the Rio Puerco in New Mexico.

J. Range Manage. 25:381-383.

Soil ripping effectively reduced runoff and caused a favorable shift in forage production from galleta to alkali sacaton. Ripping effects on runoff are shortlived, but forage production patterns may persist for 10 years.

ALDON, EARL F.

1975.

Establishing alkali sacaton on harsh sites in the Southwest.

J. Range Manage. 28:129-132.

Because of critical establishment requirements, seeds of alkali sacaton (*Sporobolus airoides*) must be planted when both soil moisture and probability of rain are high. Large seeds should be mulched to maintain moisture and darkness.

ALDON, EARL F., AND H. W. SPRINGFIELD.
1975.
Using paraffin and polyethylene to harvest water for growing shrubs.
p. 251-257. *In* Proc. Water Harvesting Symp., Phoenix, Ariz., Mar. 26-28, 1974. ARS W-22, 329 p.
Paraffin and polyethylene catchments were equally effective in harvesting runoff water from small storms in the semiarid Southwest. Soil moisture remained higher and shrub transplants grew better under both treatments, which caught an extra 0.75 inch of water during the summer rainy season.

CABLE, DWIGHT R.
1972.
Fourwing saltbush revegetation trials in southern Arizona.
J. Range Manage. 25:150-153.
Establishment and survival of saltbush was much higher on a creosotebush site, where sandy loam soil was calcareous, than on a mesquite site, where neutral sandy loam surface soil was underlain with clay or clay loam.

CABLE, DWIGHT, R., AND S. CLARK MARTIN.
1973.
Invasion of semidesert grassland by velvet mesquite and associated vegetation changes.
J. Ariz. Acad. Sci. 8:127-134.
Even with the strong deterrent of a good stand of perennial grass, velvet mesquite numbers are increasing significantly. Inevitably, gradual size and density increases of mesquite will drastically reduce perennial grass production. Prevention at minimum cost requires early and vigorous control.

HAFERKAMP, M. R., AND P. O. CURRIE.
1973.
Effects of fertilizer on root strength of Sherman big bluegrass (*Poa ampla* Merr.).
Agron. J. 65:511-512.
Pulling of plants by grazing animals has been a common problem on Sherman big bluegrass pastures in Colorado. Tensions required for pullup in the greenhouse were correlated with root weight, and significantly increased with N fertilization.

KNIGHT, DENNIS H.,* AND JOHN THILENIUS.
1975.
Vegetation ecology.
p. 37-59. *In* The Medicine Bow ecology project, final report, February 28, 1975. D. H. Knight, coord., Univ. Wyo., Laramie, for Div. Atmos. Water Resour. Manage., Bur. Reclam., U.S. Dep. Int., Denver, Colo.
Reviews the literature on vegetation ecology of the Medicine Bow mountains. Vegetation probably has not changed much since glaciation 8,000 years ago. Primary questions raised relate to effects of fire control and winter precipitation management on vegetation patterns. (Entire report available from NTIS, 397 p., $3.)

MARTIN, S. CLARK, AND DWIGHT R. CABLE.
1974.
Managing semidesert grass-shrub ranges: Vegetation responses to precipitation, grazing, soil texture, and mesquite control.
U. S. Dep. Agric. Tech. Bull. 1480, 45 p.
In a 10-year study near Tucson, Ariz., perennial grasses increased in response to favorable rainfall and mesquite control, and did better on fine- than on coarse-textured soils. Because of heavy spring use, grazing November-April was less favorable for perennial grasses than May-October or yearlong grazing.

MARTIN, S. CLARK, JOHN L. THAMES,* AND ERNEST B. FISH.*
1974.
Changes in cactus numbers and herbage production after chaining and mesquite control.
Prog. Agric. Ariz. 26(6):3-6.
In 1974, 4 years after cabling, cholla cactus numbers were less than 10 percent of original, but pricklypear was reduced by less than 15 percent. Perennial grass production was increased more by killing mesquite trees with diesel oil than by cabling.

SPRINGFIELD, H. W.
1972.
Mulching improves survival and growth of cercocarpus transplants.
USDA For. Serv. Res. Note RM-220, 4 p.
After 2 years, plants mulched with black plastic had survived and grown better than those planted in basins. Best growth, by far, resulted from using plastic mulch on a chemically prepared site, and was attributed to additional soil moisture and reduced weed competition.

SPRINGFIELD, H. W.
1972.
Using mulches to establish woody chenopods.
p. 382-391. *In* Wildland shrubs--their biology and utilization. USDA For. Serv. Gen. Tech. Rep. INT-1, 494 p.
Mulches, both natural and artificial, should be considered for establishing shrubs in difficult environments. From the standpoint of ease of application, petroleum mulches offer considerable promise for modifying temperatures in the seed zone, and conserving soil moisture.

THILENIUS, JOHN F., DIXIE R. SMITH, AND GARY R. BROWN.
1974.
Effect of 2,4-D on composition and production of an alpine plant community in Wyoming.
J. Range Manage. 27:140-142.
Use of 2,4-D almost completely eliminated *Geum rossii*. The graminoid:forb ratio of the vegetation was altered from approximately 3:7 to 8:2 without appreciably changing total standing crop or its digestible dry matter content. Resurgence of forbs could not be detected up to 4 years after treatment.

THILENIUS, JOHN F., AND GARY R. BROWN.
1974.
Long-term effects of chemical control of big sagebrush.
J. Range Manage. 27:223-224.
Ten years after spraying with 2,4-D, canopy cover of big sagebrush was 8-42 percent of pretreatment levels, herbage production was below pretreatment levels with the proportion of graminoids about equal to that prior to spraying. Effects of grazing deferment for 3 years after spraying could not be detected.

THILENIUS, JOHN F., GARY R. BROWN, AND C. COLIN KALTENBACH.*
1975.
Treating forb-dominated subalpine range with 2,4-D: Effects on herbage and cattle diets.
J. Range Manage. 28(4):311-315.
Treatment changed the grass:forb ratio from 27:73 to 81:19, but had no influence on total herbage production. Steers ate significantly more grass only the first 2 years after treatment. Steers grazing sprayed units gained an average of 2.5 lb/day; those grazing unsprayed units 2.4.

WARD, DONALD E., AND S. CLARK MARTIN.
1972.
Tanglehead--a dual purpose grass.
Ariz. Cattlelog 28(8):18-20.
Tanglehead is most valuable as emergency forage and as a gully healer. In the long run, its value as a gully healer may be the more important role.

Reclamation Techniques

ALDON, EARL F.
1973.
Revegetating disturbed areas in the semiarid Southwest.
J. Soil Water Conserv. 28:223-225.
Fourwing saltbush and alkali sacaton, excellent soil stabilizers and nutritious forage plants, can be established on floodplain areas with less than 10 inches annual rainfall, if prescribed steps are followed. Sacaton is seeded, while saltbush seedlings are transplanted. Timing is critical.

ALDON, EARL F., O. D. KNIPE, AND GEORGE GARCIA.
1973.
Revegetating devastated sites in New Mexico with western wheatgrass transplants.
USDA For. Serv. Res. Note RM-243, 3 p.
Western wheatgrass (*Agropyron smithii* Rydb.) survived well and produced daughter plants from rhizomes during the first year when good seeds were grown to 3-month-old transplants, then transferred to sandy or clay loam sites at elevations of around 7,500 feet.

ALDON, EARL F., AND H. W. SPRINGFIELD.
1973.
Revegetating coal mine spoils in New Mexico: A laboratory study.
USDA For. Serv. Res. Note RM-245, 4 p.
Emergence and early growth of mountain rye and fourwing saltbush were studied in untreated 3-year-old mine spoils, and in spoils to which organic matter or fertilizer had been added under greenhouse conditions. Emergence and growth were satisfactory from untreated spoils; adding amendments had no effect on seedling emergence or early growth.

ALDON, EARL F.
1974.
Problems and techniques in revegetating coal mine spoils in New Mexico.
Soc. Range Manage. [Tucson, Ariz., Feb. 1974] Abstr. of Pap. 27:27.
Tests thus far have revealed no toxicity to the germination or early growth of native shrubs and grasses. Fertilizer and soil amendments had no effect on seedling emergence or first month's growth, but fertilizer is increasing growth after 3 months.

ALDON, EARL F., H. W. SPRINGFIELD, AND GEORGE GARCIA.
1975.
Can soil amendments aid revegetation of New Mexico coal mine spoils?
USDA For. Serv. Res. Note RM-292, 7 p.
Adding amendments did not improve seedling emergence in greenhouse tests with mountain rye, fourwing saltbush, and western wheatgrass. Shredded bark depressed herbage yields, especially where no fertilizer was supplied. Fertilizer consistently increased yield. Topsoil was not always a better growth medium than spoil.

ALDON, EARL F.
1975.
Endomycorrhizae enhance survival and growth of fourwing saltbush on coal mine spoils.
USDA For. Serv. Res. Note RM-294, 2 p.
Atriplex canescens is a valuable shrub for domestic livestock and wildlife, and protects soil from wind and water erosion in semiarid areas, beneficial features for coal mine spoil reclamation. Inoculation of saltbush seedlings with *Glomus mosseae* improves transplanting success.

ALDON, EARL F.
1975.
Techniques for establishing native plants on coal mine spoils in New Mexico.
p.21-28. *In* Third Symp. on Surf. Min. and Reclam., Vol. 1. NCA/BCR Coal Conf. and Expo II [Louisville, Ky., Oct. 1975.] Natl. Coal Assoc., Wash., D.C. 243 p.
Direct seeding of native species has succeeded when weather was favorable, but precipitation often is deficient and erratic. Irrigation during the first year is necessary for plant establishment where precipitation averages less than 8 inches. The drip system appears effective. Water harvesting can provide supplemental water on drier sites.

ALDON, EARL F., AND H. W. SPRINGFIELD.
1975.
Problems and techniques in revegetating coal mine spoils in New Mexico.
p. 122-132. *In* Practices and problems of land reclamation in western North America. Mohan K. Wali, ed. Univ. N.D. Press, Grand Forks. 196 p.
Plant establishment on graded spoils is possible, but sometimes difficult. Irrigation is essential the first year. Sprinkler and drip irrigation have been tested, as has water harvesting to maintain vegetation. Also being studied are organic and chemical spoil amendments and mycorrhizae. Native plant species seem best for reclamation.

ALDON, EARL F., H. W. SPRINGFIELD, AND DAVID G. SCHOLL.
1976.
Fertilizer response of alkali sacaton and fourwing saltbush grown on coal mine spoil.
USDA For. Serv. Res. Note RM-306, 4 p.
Adding N or P alone at any level had little effect on greenhouse yields. Combined application of N and P, however, increased yield two to three times in both species. Yield responses differed between species depending on both relative amount of N or P in the mix and the time of application.

ORR, HOWARD K.
1975.
Mine spoil reclamation research at the Belle Ayr mine, northeast Wyoming.
Proc. Fort Union Coal Field Symp., vol. 3: Reclamation section. p. 304-307. [Mont. Acad. Sci., Billings, Apr. 1975.]
Revegetation research with shrubs and trees has been moderately successful. Moisture is the most apparent limiting factor. Risk of failure in any year is high enough to warrant such added efforts as trickle irrigation, containerized planting stock, mulching.

THILENIUS, JOHN F., AND GARY B. GLASS.*
1974.
Surface coal mining in Wyoming: Needs for research and management.
J. Range Manage. 27:336-341.
Wyoming ranks second in the nation in strippable coal resources, with at least 18.9 billion recoverable tons. Mining it could disturb about 590 square miles. Renewable resource research and management face a challenge to allow use of the coal without lasting detrimental effects on other resources.

YAMAMOTO, TERUO.
1975.
Trend surface analysis of Powder River Basin, Wyoming-Montana.
Proc. Fort Union Coal Field Symp., vol. 3: Reclamation section. p. 280-288. [Mont. Acad. Sci., Billings, Apr. 1975.]
Trend surface analysis is a mathematical technique which provides insights into strip-mine reclamation questions such as: What are feasible and esthetically pleasing surface drainage patterns and landscape designs? What changes can be expected in surface and subsurface hydrology?

YAMAMOTO, TERUO.
1975.

Coal mine spoil as a growing medium: AMAX Belle Ayr South Mine, Gillette, Wyoming.
p. 49-61. *In* Third Symp. on Surf. Min. and Reclam., Vol. 1. NCA/BCR Coal Conf. and Expo II [Louisville, Ky., Oct. 1975.] Natl. Coal Assoc., Wash., D.C. 243 p.

Although slightly more saline than surrounding soils, spoil salinity was not enough to severely limit plant growth or survival. General nutrient status was low, but loamy texture was favorable. Favorable growth is expected on these spoils.

Range Pests

LAYCOCK, W. A., AND B. Z. RICHARDSON.*

1976.

The role of pocket gophers on subalpine rangelands.
Soc. Range Manage. [Omaha, Nebr., Feb. 1976] Abstr. of Pap. 29:43.

Recovery on depleted high-elevation rangelands is very slow. Gophers influence rate of vegetal succession on overgrazed rangeland, and have a small effect on nutrient content and porosity of soils.

TURNER, G. T., R. M. HANSEN,* V. H. REID,* H. P. TIETJEN,* AND A. L. WARD.

1973.

Pocket gophers and Colorado mountain rangeland.
Colo. State Univ. Exp. Stn. Bull. 554S, 90 p.

Summarizes research by 18 scientists over a 15-year period. Results are presented in separately authored chapters on distribution and adaptation; population biology; food habits and competition; effects on the range; 2,4-D, vegetation, and pocket gophers; and control.

Habitat Evaluation: Mammals

BOEKER, ERWIN L.,* VIRGIL E. SCOTT,* HUDSON G. REYNOLDS, AND BYRON A. DONALDSON.*

1972.

Seasonal food habits of mule deer in southwestern New Mexico.
J. Wildl. Manage. 36:56-63.

Deer apparently subsist satisfactorily on a diet dominated by browse species, of which birchleaf mountainmahogany and oaks are most important. Forbs are an important supplement, especially during years with favorable spring and summer rain.

CLARY, WARREN P.

1972.

A treatment prescription for improving big game habitat in ponderosa pine forests.
p. 25-28. *In* 16th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1972] Proc. Ariz. Water Comm. Rep. 2, 43 p. Phoenix, Ariz.

Treatments are designed to determine possible differences in wildlife responses to created openings in managed and unmanaged forests. One-fifth of the managed timber area will be in permanent openings of 1 to 10 acres; one-third of unmanaged forest will be in such openings.

FFOLLIOTT, PETER F.,* WARREN P. CLARY, AND FREDERIC R. LARSON.

1976.

Observations of beaver activity in an extreme environment.
Southwest. Nat. 21(1):131-133.

Beaver were observed near small perennial pools formed in normally dry drainages dissecting desertscrub and riparian hardwood vegetation types on Dry Beaver drainage in north-central Arizona.

GOODWIN, GREGORY A.

1975.

Seasonal food habits of mule deer in southeastern Wyoming.
USDA For. Serv. Res. Note RM-287, 4 p.

Fecal analysis showed mule deer diets consisted of 87.6 percent browse, 5.6 percent graminoids, and 6.6 percent forbs. Deer ate as much as 19 percent graminoids in May, 36 percent forbs in June, and 96 percent browse in winter. Most important were big sagebrush, antelope bitterbrush, and true mountainmahogany.

JOHNSON, PHIL.

1974.

Food for deer.
Colo. Outdoors 23(1):12-14.

In 1967, the Forest Service, Colorado Division of Wildlife, and Colorado State University began cooperative research to find improved methods for managing deer winter ranges in the central Rockies. This article briefly describes the research conducted by each agency with emphasis on Forest Service nutrition and food production studies.

KUFELD, ROLAND C.,* O. C. WALLMO, AND CHARLES FEDDEMA.

1973.

Foods of the Rocky Mountain mule deer.
USDA For. Serv. Res. Pap. RM-111, 31 p.

Literature on food habits was reviewed to compile listings of reported foods of this species throughout its range. Relative importance of a plant species is indicated on the basis of its contribution to the diet in 99 studies.

KUNDAELI, JOHN N.,* AND HUDSON G. REYNOLDS.

1972.

Desert cottontail use of natural and modified pinyon-juniper woodland.
J. Range Manage. 25:116-118.

Pinyon-juniper woodland is often cleared to improve grazing for livestock. In southern New Mexico, cottontail habitat can be maintained during clearing operations by preserving some combination of 70-90 down, dead trees and living shrubs per acre.

PATTON, DAVID R.

1974.

Patch cutting increases deer and elk use of a pine forest in Arizona.
J. For. 72:764-766.

Deer and elk benefited when harvesting of ponderosa pine--the major commercial timber species in the Southwest--made a monotonous forest more diverse. Small, irregular, clearcut patches adjacent to scattered stands of saplings, poles, and sawtimber produced increases in grasses, forbs, and browse.

PATTON, DAVID R.

1975.

Nest use and home range of three Abert squirrels as determined by radio tracking.
USDA For. Serv. Res. Note RM-281, 3 p.

Abert squirrels have and use more than one nest in their home range. Three squirrels used 2, 5, and 6 nests in areas of 30, 10, and 85 acres, respectively.

PATTON, DAVID R.

1975.

Abert squirrel cover requirements in southwestern ponderosa pine.
USDA For. Serv. Res. Pap. RM-145, 12 p.

Describes characteristics of ponderosa pine trees and stands selected by the Abert squirrel for cover, including basal area, tree density and size, tree vigor, dominance and age class, nest location, and nest tree density.

PATTON, DAVID R., AND PETER F. FFOLLIOTT.*
1975.
Selected bibliography of wildlife and habitats for the Southwest.
USDA For. Serv. Gen. Tech. Rep. RM-16, 39 p.
Contains 390 selected references on research and management of important wildlife species and habitats in Arizona and New Mexico, covering a period from 1913 to early 1975. A subject index is keyed to an alphabetical list of authors.

RATCLIFF, THOMAS D.,* DAVID R. PATTON, AND PETER F. FFOLLIOTT.*
1975.
Ponderosa pine basal area and the Kaibab squirrel.
J. For. 73:284-286.
A measured squirrel population index was most consistently associated with basal area of ponderosa pine, including all pines and pines over 6 inches d.b.h. A model for assessing quality of squirrel habitat was formulated.

REGELIN, WAYNE L., AND OLOF C. WALLMO.
1975.
Carbon black increases snowmelt and forage availability on deer winter range in Colorado.
USDA For. Serv. Res. Note RM-296, 4 p.
Use of carbon black offers potential for increasing the availability of deer forage on winter ranges. On slopes with a southern exposure, over 40 cm of snow was melted to bare ground in February when air temperature averaged -8.8C during daylight hours.

REYNOLDS, HUDSON G.
1974.
Habitat research...cornerstone in management.
N. Mex. Wildl. 19(1):28-30.
To survive and reproduce, each species of wildlife requires specific living conditions or places of feeding, breeding, resting, playing, and refuge. If research can determine the kind, amount, and dispersion of plants to supply these habitat requirements, wildlife populations are assured.

THILENIUS, JOHN F.
1972.
Classification of deer habitat in the ponderosa pine forest of the Black Hills, South Dakota.
USDA For. Serv. Res. Pap. RM-91, 28 p.
The ponderosa pine forest was classified into 13 habitat units by cluster analysis of a similarity matrix based on the vegetation, soil, and site attributes of 100 randomly located sample stands. Habitat units were defined at a minimum similarity of 60 percent. The comparative use of the habitats by deer was evaluated by analysis of variance of long-term (9 years) data on deer pellet group densities in the sample stands.

TURKOWSKI, FRANK J.
1975.
Dietary adaptability of the desert cottontail.
J. Wildl. Manage. 39(4):748-756.
Desert cottontails apparently can survive mainly on dry grasses and forbs, using cactus and forbs with high moisture contents as a source of water. Grasses contributed 38 percent of the dietary bulk, forbs 41 percent, and shrubs 21; 43 plant species or genera were identified in stomach contents.

URNESS, PHILIP J.
1974.
Deer use changes after root plowing in Arizona chaparral.
USDA For. Serv. Res. Note RM-255, 8 p.
Deer spent one-fourth to one-half as much time on root-plowed chaparral pastures seeded to lovegrass as in adjacent brushfields. Although high-quality forbs increased greatly on treated southerly exposures, deer showed no apparent preference for those slopes.

WALLMO, OLOF C., WAYNE L. REGELIN, AND DONALD W. REICHERT.
1972.
Forage use by mule deer relative to logging in Colorado.
J. Wildl. Manage. 36:1025-1033.
A lodgepole pine, spruce-fir forest was clearcut in narrow strips alternating with uncut strips. Forage production 15 years later was 47 percent greater on cut strips. Tame deer obtained 63.3 percent of their forage from cut strips, 27.4 percent from uncut strips, and 9.3 percent from logging roads.

WALLMO, OLOF C.
1975.
Important game animals and related recreation in arid shrublands of the United States.
p. 98-107. *In* Arid Shrublands. Proc. Third Workshop of U.S./Aust. Rangelands Panel, Tucson, Ariz., Mar. 26-Apr. 5, 1973. 148 p.
Reviews environmental and biological factors that affect welfare of game animals, and identifies some aspects of their use as a recreational resource. Progressive loss of wildlands probably is the major factor influencing abundance and diversity of wildlife in western U.S.

WARD, A. LORIN.
1973.
Sagebrush control with herbicide has little effect on elk calving behavior.
USDA For. Serv. Res. Note RM-240, 4 p.
Elk did not change their calving behavior or feeding habits on a site where 96.7 percent of the big sagebrush (*Artemisia tridentata*) cover had been killed with 2 pounds acid equivalent of 2,4-D herbicide.

WARD, A. L., K. DIEM,* AND R. WEEKS.*
1975.
The impact of snow on elk.
p. 105-133. *In* The Medicine Bow ecology project, final report, February 28, 1975. D. H. Knight, coord., Univ. Wyo., Laramie, for Div. Atmos. Water Resour. Manage., Bur. Reclam., U.S. Dep. Int., Denver, Colo.
Elk can paw through relatively deep light snow for food. Ice layers and deeper snow create difficulties. If target areas for increasing snow through weather modification are above elk winter range, 30 percent more snow accumulation should have no adverse effects. (Entire report available from NTIS, 397 p., $3.)

Habitat Evaluation: Birds and Fish

BEAVER, DONALD L.,* AND PAUL H. BALDWIN.*
1975.
Ecological overlap and the problem of competition and sympatry in the western and Hammond's flycatchers.
Condor 77(1):1-13.
The western flycatcher displaced the Hammond's to some degree from aspen-conifer habitat. Thus the western flycatcher appears to be the superior competitor in this area (Wet Mountains of southern Colorado). Local coexistence is most likely temporary and unstable.

EVANS, KEITH E., AND ROGER R. KERBS.
1972.
Some birds of Jackson County, South Dakota.
S. D. Bird Notes 24(4):76-77, 81. (Whole No. 95).
During 98 visits to 12 study ponds in a 6-year period, 13,432 waterfowl, 1,066 shorebirds, and 62 other bird species were counted.

LENNARTZ, MICHAEL R.,* AND ARDELL J. BJUGSTAD.
1975.
Information needs to manage forest and range habitat for nongame birds.
p. 328-333. *In* Proc. Symp. Manage. For. Range Habitats for Nongame Birds [Tucson, Ariz., May 1975]. USDA For. Serv. Gen. Tech. Rep. WO-1, 343 p. Wash., D.C.
Highlights the management information and research needs as pointed out in previous papers of this Proceedings, and comments submitted from land managers. A consensus is implied that management of nongame birds and their habitats is a relatively new resource issue, and available information is badly scattered.

SCHROEDER, MAX H.,* AND DAVID L. STURGES.
1975.
The effect on the Brewer's sparrow of spraying big sagebrush.
J. Range Manage. 28(4):294-297.
Three Brewer's sparrow nests in plants sprayed with 2,4-D were apparently unaffected. Sparrow use of a sprayed sagebrush stand 1 and 2 years after spraying, however, was 67 and 99 percent lower, respectively, than on an unsprayed stand; no evidence of nesting was found on the sprayed stand.

SCOTT, VIRGIL E.,* AND DAVID R. PATTON.
1975.
Cavity-nesting birds of Arizona and New Mexico forests.
USDA For. Serv. Gen. Tech. Rep. RM-10, 52 p.
Summarizes published data and personal observations of nesting and food habits of 41 species of cavity-nesting birds in five southwestern forest types.

Wildlife Anatomy, Physiology, Reproduction

EVANS, KEITH E., AND AARON N. MOEN.*
1975.
Thermal exchange between sharp-tailed grouse (*Pedioecetes phasianellus*) and their winter environment.
Condor 77(2):160-168.
Maintenance metabolic rate, weight change features, effective surface area, thermal transfer properties, thermoregulatory behavior, wind velocity, and ambient temperature were analyzed to predict energy requirements.

NAGY, J. G.,* AND W. L. REGELIN.
1975.
Comparison of digestive organ size of three deer species.
J. Wildl. Manage. 39(3):621-624.
Roe (*Capreolus capreolus*), red (*Cervus elaphus*), and fallow deer (*Cervus dama*) collected in Hungary were compared. The relative rumen-reticulum tissue weight as a percentage of body weight was similar for all three species. As specie's body size increased, relative weight of omasal tissue increased, and abomasum tissue decreased.

REYNOLDS, HUDSON G.
1972.
An albino Gambel quail from southern Arizona.
J. Ariz. Acad. Sci. 7:46.
This record, a male collected Dec. 17, 1970 near Helvetia, is the first known report of albinism in Gambel quail.

REYNOLDS, HUDSON G., AND FRANK TURKOWSKI.
1972.
Reproductive variations in the round-tailed ground squirrel as related to winter rainfall.
J. Mammal. 53: 893-898.
Dates of inception of breeding and number of embryos per litter are strongly correlated with the 2- to 5-month rainfall period preceding the February through April breeding season.

SEVERSON, KIETH E., HAROLD E. MESSNER, AND DONALD R. DIETZ.
1972.
Two-headed white-tailed deer fetus.
Am. Midl. Nat. 88:464-465.
This paper reports the occurrence and physical characteristics of a two-headed white-tailed deer (*Odocoileus virginianus dakotensis* Goldman and Kellogg) fetus taken from a 3-1/3-year-old doe in western South Dakota.

WATKINS, ROSS K., AND PHILIP J. URNESS.
1972.
Maxillary canine and supernumerary incisors in Arizona Coues white-tailed deer.
Southwest. Nat. 17:211-213.
No earlier reports of either dental anomaly have been found in the literature for this race. Apparently it does not follow the general pattern of increased incidence of maxillary canines in white-tailed deer populations at southern latitudes.

Wildlife Nutrition

DIETZ, DONALD R.
1972.
Nutritive value of shrubs.
p. 289-302. *In* Wildland shrubs--their biology and utilization. USDA For. Serv. Gen. Tech. Rep. INT-1, 494 p.
Shrubs are important sources of protein, carbohydrate, and minerals for most classes of wild herbivores, especially during winter. Shrubs are highly digestible during plant growth, but become more difficult to digest as the cell walls become lignified.

EVANS, KEITH E.
1972.
Energetics of sharp-tailed grouse during winter.
Soc. Range Manage. [Wash., D.C., Feb. 1972] Abstr. of Pap. 25:24.
Winter energetics were analyzed within a mathematical framework for predicting energy requirements, feed intake, and weight changes at varying temperatures and wind velocities, thus establishing a base for management decisions involving food and cover for sharp-tails on northern Great Plains ranges.

EVANS, KEITH E., AND DONALD R. DIETZ.
1974.
Nutritional energetics of sharp-tailed grouse during winter.
J. Wildl. Manage. 38:622-629.
In ad libitum feeding trials, adult grouse ingested more fleshy hawthorn berries than any of six other foods. Silver buffaloberry was the best native winter food tested. Food consumed provided metabolizable energy in excess of 1.5 times basal metabolic rate.

MC CULLOCH, CLAY Y.,* AND PHILIP J. URNESS.
1973.
Deer nutrition in Arizona chaparral and desert habitats.
Ariz. Game and Fish Dep. Spec. Rep. 3, 68 p.
This three-part study--seasonal diets of mule and white-tailed deer, chemical analyses and in vitro digestibility of seasonal deer forages, and nutritional value of seasonal deer diets--indicates forage quality is not responsible for recent poor fawn survival. Inhibited phosphorus metabolism is suspect, however.

NAGY, J. G.,* AND O. C. WALLMO.
1973.
Deer nutrition problems in the U.S.A.
Proc. World Exhib. Hunting, Int. Sci. Conf. Game Manage., [Budapest, Sept. 1971] Sect. 1, p. 59-68. Univ. Press, Sopron, Hung.
Reviews the history of deer population and habitat management problems in the U.S., the development of knowledge of nutritional requirements of deer, and application of such knowledge to habitat management.

REGELIN, WAYNE L., OL F C. WALLMO, JULIUS G. NAGY,* AND DONALD R. DIETZ.
1974.
Effect of logging on forage values for deer in Colorado.
J. For. 72:282-285.
Crude protein content, moisture content, and digestibility did not differ statistically between clearcut and uncut strips. Because of greater species diversity and plant productivity, and because deer spent more time grazing in clearcut strips, they obtained over twice as much of their crude protein and digestible dry matter there.

URNESS, P. J., D. J. NEFF,* AND R. K. WATKINS.
1975.
Nutritive value of mule deer forages on ponderosa pine summer range in Arizona.
USDA For. Serv. Res. Note RM-304, 6 p.
Chemical analyses and apparent in vitro dry matter digestibilities were obtained for monthly diets. Relative values were calculated, based on nutrient contents and percentage composition in the diet. These data will help land managers assess impacts of vegetation management on mule deer habitat, and in designing habitat improvements.

URNESS, P. J., D. J. NEFF,* AND J. R. VAHLE.
1975.
Nutrient content of mule deer diets from ponderosa pine range.
J. Wildl. Manage. 39(4):670-673.
Nutritional quality declined sharply from high levels in spring to moderate by late summer, but not enough to suggest deficiencies. Overall quality of summer diets was quite good. Very high values during late gestation should assure good milk production and optimum fawn production.

Experimental and Analytical Techniques

CUPAL, JERRY J., A. LORIN WARD, AND RICHARD W. WEEKS.*
1974.
A repeater type biotelemetry system for use on wild big game animals.
Eleventh Annu. Rocky Mt. Bioeng. Symp. and Eleventh Int. ISA Biomed. Sci. Instrum. Symp. [Colo. Springs, Colo., Apr. 1974] Proc., Biomed. Sci. Instrum. 10:145-152.
The telemetry system consists of an implanted heat-flow-rate sensing transmitter, a repeater-type neck collar which sensed the pulses from the implant and retransmitted them, and a portable receiving station consisting of a receiver, decoding circuitry, and analog chart recorder. Field experience has been short but satisfactory.

DIEM, KENNETH L.,* A. LORIN WARD, AND JERRY J. CUPAL.*
1974.
Cameras as remote sensors of animal activities.
XIth Int. Congr. Game Biol. [Stockholm, Sweden, Sept. 1973] Pap., 10 p.
A Super-8 mm remote time-lapse system combines simplicity, durability, economy, and good image characteristics, although 35 mm systems may be more appropriate in some instances. Careful construction and electronic circuitry are critical.

HILLER, PAUL K.,* RICHARD W. WEEKS,* JERRY J. CUPAL, AND A. LORIN WARD.
1974.
An automatic wildlife tracking system.
Eleventh Annu. Rocky Mt. Bioeng. Symp. and Eleventh Int. ISA Biomed. Sci. Instrum. Symp. [Colo. Springs, Colo., Apr. 1974] Proc. Biomed. Sci. Instrum. 10:157-160.
Describes development work on a system to be used in airplanes or four-wheel-drive vehicles. It is capable of tracking a low-duty cycle pulse signal, and gives direction on a pulse-by-pulse basis. Performance is not yet entirely satisfactory, but proves validity of concepts.

KOVNER, J. L., AND S. A. PATIL.
1974.
Properties of estimators of wildlife population density for the line transect method.
Biometrics 30:225-230.
The variance of several estimators of the population density based on the line transect method of distance sampling are studied under exponential sighting probability. The estimator suggested by Gates (1969) is shown to be minimum variance unbiased estimator. Efficiency of other estimators is obtained with respect to this estimator.

LAVIN, FRED,* AND O. D. KNIPE.
1975.
Drip pan for field plot sprinkle irrigation.
J. Range Manage. 28:155-157.
This drip pan, developed for uniformly irrigating small field plots in remote locations by simulated rainfall, is inexpensive to build, easily operated by one man, sturdy, portable, clog resistant, and adaptable to a wide variety of conditions.

PARKER, H. DENNISON, JR., AND JAMES C. HARLAN.*
1972.
Solar radiation affects radiant temperatures of a deer surface.
USDA For. Serv. Res. Note RM-215, 4 p.
Variation in effective radiant temperature (ERT) of a deer hide, when sunlit and shaded, was measured with an infrared radiometer. Mean decrease in ERT was 18.3 C. in 120 seconds after shade was applied. Deer detection by an airborne thermal infrared scanner should be conducted during periods of no direct-beam solar radiation, that is, sunset to dawn.

PARKER, H. DENNISON, JR.
1972.
Environmental factors affecting detection of wild deer with an airborne thermal infrared scanner.
Soc. Range Manage. [Wash., D.C., Feb. 1972] Abstr. of Pap. 25:33.
Multiple regression analysis indicated air temperature was the environmental factor most closely associated with the effective radiant temperature (ERT) of deer, snow, sagebrush, rock, and bare soil. Solar radiation had a marked but highly variable effect. Thermal contrast between deer and snow was always in excess of 2C.

PARKER, H. DENNISON, JR., AND RICHARD S. DRISCOLL.
1972.
An experiment in deer detection by thermal scanning.
J. Range Manage. 25:480-481.
An airborne, thermal infrared scanner was tested for deer detection over penned mule deer (*Odocoileus hemionus hemionus*) near Fort Collins, Colorado. The animals were detected at 300- and 500-foot altitudes, but not at 1,000 feet.

PATTON, DAVID R., VIRGIL E. SCOTT,* AND ERWIN L. BOEKER.*

1972.

Construction of an 8-mm time-lapse camera for biological research.

USDA For. Serv. Res. Pap. RM-88, 8 p.

A time-lapse camera for use in biological research can be constructed from a super 8-mm movie camera. A single-frame release is activated through a solenoid controlled by an electronic timer. The unit is activated by a photo cell for daylight operation. Timing interval can be varied from 1/2 second to 60 minutes. With a 5-minute interval and 12 hours of daylight, one roll of film will last 25 days. The unit operates from a 6-volt d.c. power supply. Cost of camera, solenoid, and electronic timer is approximately $165.

PATTON, DAVID R., DAVID W. BEATY,* AND RONALD H. SMITH.*

1973.

Solar panels: An energy source for radio transmitters on wildlife.

J. Wildl. Manage. 37:236-238.

A panel constructed of 24 commercial grade silicon cells is capable of charging a 7.5 volt (180 ma capacity) nickel-cadmium battery for day and night operation, or an electrolytic capacitor for day operation only. The panel measures 5.71 cm x 4.44 cm x .63 cm and costs $55.

PATTON, DAVID R., HOWARD G. HUDAK,* AND THOMAS D. RATCLIFF.*

1976.

Trapping, anesthetizing, and marking the Abert squirrel.

USDA For. Serv. Res. Note RM-307, 2 p.

Folding live traps placed at 250-foot intervals on a 1,000-foot grid provide a density of approximately two traps per acre for capturing the Abert squirrel. Procedures are described for anesthetizing squirrels for physical examination. Squirrels are marked with ear tags and colored collars.

PIATT, J. R.,* AND H. W. SPRINGFIELD.

1973.

Tetrazolium staining of cliffrose embryos.

Proc. Assoc. Off. Seed Anal. 63:67-75.

Staining embryos for 2 hours in a 0.5 percent TTC solution at 40 degrees C gives near-optimum results in terms of rapidity and intensity of staining. Embryos must be almost completely stained a dark red to be considered germinable.

REICHERT, DONALD W.

1972.

Rearing and training deer for food habits studies.

USDA For. Serv. Res. Note RM-208, 7 p.

Wild does are trapped in winter. Fawns are left with the doe at least 12 hours to assure feeding of colostrum, but less than 24 hours. Reliance on the human trainer develops through bottle feeding and frequent contact. Training for field use requires 4 to 6 weeks.

TURNER, GEORGE T.

1972.

A new approach to estimating herbage moisture content.

J. Range Manage. 25:229-231.

Moisture contents of different species of range plants growing under generally similar conditions are closely related during the period of peak herbage development. From regression equations that express those relationships, moisture content of several species can be predicted within reasonable limits from the content of one or more associated species.

URESK, DANIEL W., DONALD R. DIETZ, AND HAROLD E. MESSNER.

1975.

Constituents of in vitro solution contribute differently to dry matter digestibility of deer food species.

J. Range Manage. 28(5):419-421.

Apparent digestibility was lowest, 29 percent, for water alone, buffer alone, and buffer plus pepsin. Dry matter loss increased to 33 percent with buffer + alcohol + HCl. Highest apparent digestibility, 44 percent, was reached with the addition of white-tailed deer inoculum. HCl contributed significantly to digestion while pepsin did not.

WALLMO, O. C., R. B. GILL,* L. H. CARPENTER,* AND D. W. REICHERT.

1973.

Accuracy of field estimates of deer food habits.

J. Wildl. Manage. 37:556-562.

The 'grazing minutes' method of determining food habits was tested by observing tame mule deer at close range. Use of shrubs was overestimated, while grasses and forbs were underestimated. With the 'feeding site' method, use of shrubs and forbs was underestimated, while grasses were overestimated.

WEEKS, RICHARD W.,* A. LORIN WARD, AND JERRY CUPAL.*

1972.

A telemetry system for studying elk behavior in the Rocky Mountains.

Ninth Ann. Rocky Mt. Bioeng. Symp. and Tenth Int. ISA Biomed. Sci. Instrum. Symp. [Omaha, Nebr., May 1972] Proc., Biomed. Sci. Instrum. 9:177-181.

The electronic circuit design is a combination of multivibrator timing control and the Cochran or Squegging oscillator. The antenna chosen was a circular, half-wave dipole. The system has been used for 1 year on six cow elk in southeastern Wyoming.

WEEKS, RICHARD W.,* JERRY J. CUPAL,* AND A. LORIN WARD.

1972.

Telemetry tracking of summer transplanted elk in south central Wyoming.

Int. Telem. Conf. [Los Angeles, Calif., Oct. 1972] Proc. 1972:238-244.

Generally, elk are trapped and transplanted in winter. A telemetry system developed for use on elk is described, along with behavior of elk transplanted during summer. The rutting season appears to be an optimum time for transplanting elk.

Multiple Use Relations

CLARY, WARREN P., WILLIAM H. KRUSE, AND FREDERIC R. LARSON.

1975.

Cattle grazing and wood production with different basal areas of ponderosa pine.

J. Range Manage. 28(6):434-437.

Beef gain potential was maximum at zero basal area, and was one-third less when ponderosa pine was present at basal areas of 20 square feet per acre. The combined economic value of grazing and saw-log production would be maximum in tree stands having a basal area of about 45 to 60 square feet per acre.

FFOLLIOTT, PETER F.,* AND DAVID R. PATTON.

1975.

Production-rating functions for Abert squirrels in southwestern ponderosa pine.

Wildl. Soc. Bull. 3(4):162-165.

Production-rating functions for Abert squirrel food and nest trees and for ponderosa pine tree volume were plotted against one another to form decisionmaking models for identifying conflicts between use. The graphs show competitive stages, where the value of one improves while the other declines.

MARTIN, S. CLARK.

1972.

Semidesert ecosystems--who will use them. How will we manage them.

Soc. Range Manage. [Wash., D.C., Feb. 1972] Abstr. of Pap. 25:16.

Maximum sustained production of forage and beef no longer is an adequate objective for management of southwestern semidesert ranges; nonrancher interests are claiming an increasing voice in their management. Recreational activities may supplement ranch income from livestock.

MARTIN, S. CLARK.

1975.

Why graze semidesert ranges?

J. Soil Water Conserv. 30(4):186-188.

Population increases are dramatically changing land use in the arid Southwest. Range livestock, however, require little fossil fuel to make high-quality food from forage that is otherwise uneconomical to harvest. Good grazing management can control erosion, and improve forage, wildlife habitat, esthetics, and recreation.

REYNOLDS, HUDSON G.

1972.

Wildlife habitat improvement in relation to watershed management in the Southwest.

p. 10-17. *In* 16th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1972] Proc. Ariz. Water Comm. Rep. 2, 43 p. Phoenix, Ariz.

Describes treatment impacts on habitat, and wildlife responses in ponderosa pine, pinyon-juniper, chaparral, and riparian habitats. We can now recommend some constraints of watershed treatments that will improve wildlife habitat.

WARD, A. LORIN, JERRY J. CUPAL,* ALFRED L. LEA, CHARLES A. OAKLEY,* AND RICHARD W. WEEKS.*

1973.

Elk behavior in relation to cattle grazing, forest recreation and traffic.

North Am. Wildl. Nat. Resour. Conf. [Wash., D. C., Mar. 1973] Trans. 38:327-337.

Elk are compatible with cattle on range with adequate food, but apparently prefer to keep at least a half mile from out-of-vehicle recreationists. Elk were cautious about crossing major roads, but often grazed within 300 yards of Interstate 80.

WARD, A. LORIN.

1973.

Elk behavior in relation to multiple uses on the Medicine Bow National Forest.

West. Assoc. State Game Fish Comm. [Salt Lake City, Utah, July 1973] Proc. 53:125-141.

Telemetry was used to monitor elk behavior in relation to multiple uses on the Medicine Bow National Forest in southern Wyoming. Elk and cattle appeared to be socially compatible where there is an adequate food supply. Traffic on Forest Service systems roads has little effect on elk activity, especially beyond 300 yards. Interstate 80 acts as a barrier to elk movement. Elk preferred to be at least one-half mile from people engaged in out-of-vehicle activity such as camping, picnicking, fishing, and harvesting timber.

RECREATION

*Private, State or Federal cooperator

Avalanches: See Avalanches, Snow Physics under WATERSHED MANAGEMENT

Recreationist Behavior

BROWN, PERRY J.,* BEVERLY L. DRIVER, AND GEORGE H. STANKEY.*

1976.

Human behavioral science and recreation management.

p. 53-63. *In* XVI IUFRO World Congr., Div VI, [Oslo, Norway, June 1976] Proc. IUFRO Secr., Vienna, Austria.

The usefulness of preference and behavior information is evaluated by asking: How does such information fit into recreation management decision processes? How well have researchers done in getting necessary data? What must now be done to make the contribution of behavioral science useful to recreation management?

DRIVER, B. L.

1975.

Quantification of outdoor recreationists' preferences.

p. 165-187. *In* Research camping and environmental education. [Univ. Park, Pa., Dec. 1975]. Penn State HPER Ser. 11, 508 p.

Interprets recent research attempts to identify and measure specific types of experiences expected from particular activities. Different sets of factors influence these expectations, and the subsequent behavior they prompt.

DRIVER, B. L., AND JOHN R. BASSETT.*

1975.

Defining conflicts among river users: A case study of Michigan's Au Sable River.

Naturalist 26(1):19-23.

Perceptions of intensity and causes of conflicts between river users varied among trout fishermen, canoeists, livery owners, cottage owners, and people influential in local communities. To reduce conflicts, over half of all respondents favored developing additional rivers and distributing use more uniformly.

DRIVER, B. L., AND PERRY J. BROWN.*

1975.

A social-psychological definition of recreation demand, with implications for recreation resource planning.

p. 63-88. *In* Assessing demand for outdoor recreation, Nat. Res. Counc. Comm. on Assessment of Demand ... ed. NAS-NRC Rep. (unnumb.), Wash., D.C. 123 p.

Too little attention has been given to behavioral variables in recreation demand analyses. A general social-psychological model of recreation demand is proposed into which most theories and approaches to behavioral aspects of recreation behavior can be fitted, whether they are psychological, sociological, or physiological in nature.

Environmental Impacts

AUKERMAN, ROBERT,* AND WILLIAM T. SPRINGER.*

1976.

Effects of recreation on water quality in wildlands. Eisenhower Consortium Bull. 2, 25 p.

This study indicates that recreational use is not at present a significant cause of bacterial water pollution; turbidity and dissolved-oxygen concentrations are also unaffected. Thus recreational opportunities may be provided near water with a minimum investment. Available as PB 251104, for $4, from National Technical Information Service, Springfield, Virginia, 22151.

EISENHOWER CONSORTIUM FOR WESTERN ENVIRONMENTAL FORESTRY RESEARCH.

1975.

Man, leisure, and wildlands: A complex interaction. [Proc. First Eisenhower Consortium Res. Symp., Sept. 14-19, 1975, Vail, Colo.] Eisenhower Consortium Bull. 1, 286 p.

Limited number of copies available from the Rocky Mountain Station. Additional copies available for $9.25 from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Va. 22151. 1.

Environmental Amenities

BOSTER, RON S., AND TERRY C. DANIEL.*

1972.

Measuring public responses to vegetative management.

p. 38-43. *In* 16th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1972] Proc. Ariz. Water Comm. Rep. 2, 43 p. Phoenix, Ariz.

Esthetic judgments of random color slides, taken in areas of ponderosa pine forest subjected to an array of vegetative manipulations from clearcut to essentially natural, were evaluated in terms of the psychologists' theory of signal detection. Results appear to be valid, reliable, and useful.

BOSTER, RON S.

1973.

On the criteria for and the possibility of quantifying the aesthetic aspects of water resource projects.

p. 6-21, *In* Toward a technique for quantifying aesthetic quality of water resources. Perry J. Brown, ed. [Colloq., Park City, Utah, Oct. 1972]. Inst. Water Resour., Dep. Army, Corps Eng. PRWG-120-2, 91 p. Utah State Univ., Logan.

Introduces the colloquim problem of quantifying aesthetic aspects of water resource projects, and discusses criteria that might serve to judge solutions to the problem, related research efforts, and the 'straw man' as a possible solution framework.

DANIEL, TERRY C.,* LAWRENCE WHEELER,* RON S. BOSTER, AND PAUL R. BEST, JR.*

1973.

Quantitative evaluation of landscapes: An application of signal detection analysis to forest management alternatives.

Man-Environ. Syst. 3:330-344.

Six ponderosa pine forest areas, each representing a different vegetative treatment, were presented in a series of color slides to individuals for detection and esthetic judgment of treatments. Signal detection analyses gave systematic and reliable indices of observers' reactions to different forest landscapes.

RESOURCE ASSESSMENT AND ECONOMICS

*Private, State or Federal cooperator

Assessment (Resource Inventories, Techniques)

DRISCOLL, R. S., P. O. CURRIE, AND M. J. MORRIS.
1972.
Estimates of herbaceous standing crop by microdensitometry.
Am. Soc. Photogramm. Annu. Meet. [Wash., D. C., Mar. 1972] Proc. 38:358-364.
Green standing herbage of seeded big bluegrass was estimated from large-scale color infrared aerial photos. Because of heterogeneous plant species composition, however, native ranges will yield photos with more complex image density patterns.

DRISCOLL, R. S., P. O. CURRIE, AND M. J. MORRIS.
1972.
Estimates of herbaceous standing crop by microdensitometry.
Photogramm. Eng. 38:591. (Abstr.)
Paper presented at 38th annual meeting of American Society of Photogrammetry, Washington, D. C., March 12-17, 1972.

DRISCOLL, R. S., AND M. M. SPENCER.*
1972.
Multispectral scanner data for plant community classification.
Eighth Int. Symp. Remote Sensing Environ. [Ann Arbor, Mich., Oct. 1972] Abstr. of Pap., p. 127-128.
Recognition processing was done on a general purpose digital computer and a special purpose analog recognition computer. Generalized plant communities were acceptably discriminated, but not all specific community types were classified as belonging to their appropriate grassland systems.

DRISCOLL, R. S., AND M. M. SPENCER.*
1972.
Multispectral scanner imagery for plant community classification.
Int. Symp. Remote Sensing Environ. [Ann Arbor, Mich., Oct. 1972] Proc. 8:1259-1278.
Intensive preprocessing of spectral data was required. Generalized plant community types--forest, grassland, and hydrophytic systems--were acceptably classified. Serious, but soluble, errors occurred when classifying specific communities within the grassland system. Special clustering analyses improved these classifications.

DRISCOLL, RICHARD S., AND RICHARD E. FRANCIS.
1973.
70mm aerial photographs for range vegetation analysis.
Soc. Range Manage. [Boise, Idaho, Feb. 1973] Abstr. of Pap. 26:13.
Sampling can (1) determine areal extent of intricate plant communities, (2) detect and identify individual shrubby and herbaceous species, (3) estimate relative amounts of plant cover and bare soil, (4) estimate herbaceous standing crop, and (5) estimate population dynamics of some small mammals in relation to habitat change.

DRISCOLL, RICHARD S., JACK N. REPPERT, AND ROBERT C. HELLER.*
1974.
Microdensitometry to identify plant communities and components on color infrared aerial photos.
J. Range Manage. 27:66-70.
Image density differences can be used to discriminate individual shrub and tree species of a pinyon pine-juniper plant community. Image density was also used to identify six general plant communities. Sites and cultural treatments within native grasslands and ponderosa pine forest could not be so easily discriminated.

DRISCOLL, RICHARD S., AND MERVIN D. COLEMAN.*
1974.
Color for shrubs.
Photogramm. Eng. 40:451-459.
Identification of individual shrubs was significantly better on large-scale (1:800-1:1,500) 70-mm color-infrared aerial photographs than on normal color. Photoscales smaller than 1:2,400 had limited value except for mature individuals of relatively tall species.

DRISCOLL, RICHARD S.
1974.
Use of remote sensing in range and forest management.
Proc. Great Plains Agric. Counc. 1974:111-133.
Aerial photography of various kinds will continue to be the primary tool for remote sensing of vegetation for at least several years. Development of computerized optical-mechanical scanners looks promising, but human input is necessary in interpreting data. Usefulness of satellite imagery is uncertain.

DRISCOLL, RICHARD S., RICHARD E. FRANCIS, JAMES A. SMITH,* AND ROY A. MEAD.*
1974.
ERTS-1 data for classifying native plant communities--central Colorado.
Int. Symp. Remote Sensing Environ. [Ann Arbor, Mich., April 1974] Proc. 9:1195-1211.
Visual interpretation and machine processing of system-corrected ERTS-1 data provided similar results for classifying native plant communities to the Regional Level. Classification to the Series Level was not as successful.

DRISCOLL, RICHARD S., AND THOMAS C. WATSON.
1974.
Aerial photography for pocket gopher populations.
p. 481-492. *In* Proc. Symp. Remote Sensing and Phot74.
Aerial photography for pocket gopher populations.
p. 481-492. *In* Proc. Symp. Remote Sensing and Photo Interpretation [Banff, Alberta, Can., Oct. 1974] Int. Soc. Photogramm. Comm. VII, vol. 2, Can. Inst. Surveying, Ottawa, Ont.
Mounds of soil produced by burrowing pocket gophers, which are highly correlated with population density, were interpreted from color and color-infrared aerial photos. Population estimates from 1:600 scale color-infrared photos were 97 percent as accurate as estimates from ground evaluations.

DRISCOLL, RICHARD S., AND RICHARD E. FRANCIS.
1975.
Range inventory: Classification of plant communities.
p. 26-43. *In* Evaluation of ERTS-1 data for forest and rangeland surveys. USDA For. Serv. Res. Pap. PSW-112, 67 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.
Tests showed data gathered by the first Earth Resources Technology Satellite would be useful to managers of large forest ownerships. Forest and nonforest lands were distinguished with 90-95 percent accuracy. Forest disturbances could be detected with 90 percent accuracy when ERTS data were compared with aerial photos.

Land Use Alternatives

LEWIS, GORDON D.
1973.
Social influences on forest exploitation.
Seventh World For. Congr. [B. Aires, Argent., Oct. 1972] Proc. Prepr. 7CFM/C:III/1E, 7 p.
Developing nations need to utilize forests to improve incomes and provide physical needs. As nations develop, however, demands for noneconomic products and services of the forests increase. Allocation of forest lands to production of specific products and benefits may meet present needs while providing for future use.

LEWIS, GORDON D.
1974.
Land use planning activities in the Forest Service.
p. 16-21, *In* Impact of Land Use Planning Semin. Proc. Great Plains Agric. Counc. Publ. 69.
Resource management guides for Federal land management agencies now require more comprehensive land-use planning. Because the new process must identify, quantify, evaluate, and coordinate a complex combination of overlapping and independent ecological, social, and economic systems, planning must be done by an interdisciplinary team aided by public input.

LEWIS, GORDON D.
1975.
Major problems in rural development unique to the Great Plains: A panel.
p. 108-112. *In* Rural development in the Great Plains: Problems and potentials. Great Plains Agric. Counc. Publ. 75, 140 p.
Development will result from increased recreation and mineral extraction. New concepts, regulations, and laws on land ownership, land use and reclamation, and water quality and quantity are required if we are to avoid extensive environmental damage. Social and economic considerations must be evaluated to guide land use planners.

O'CONNELL, PAUL F., AND RON S. BOSTER.
1974.
Demands on National Forests require coordinated planning.
Ariz. Rev. 23(2):1-7.
Alternative uses and increasing resource scarcity require a change from basing allocation policies on simple physical characteristics of resources to the use of economic criteria. Production decisions must consider economic demand as well as supply. The Mogollon Rim study in Arizona illustrates use of economic values.

TURNER, JAMES M.
1974.
Allocation of forest management practices on public lands.
Ann. Reg. Sci. 8(2):72-88.
Describes a process for integrating product yields, costs, and values into a planning framework which broadly defines management practices on National Forest lands.

Resource Management Economics

BOSTER, RON S., PAUL F. O'CONNELL, AND JAMES C. THOMPSON.
1974.
Recreation uses change Mogollon Rim economy.
Ariz. Rev. 23(8,9):1-7.
An economy based on cattle and wood has changed to one based on second homes, retirement living, and transient recreation. Safeguards are inadequate to prevent environmental degradation associated with rapid population and economic growth. The problems and solutions are equally complex.

BROWN, THOMAS C., PAUL F. O'CONNELL, AND ALDEN R. HIBBERT.
1974.
Chaparral conversion potential in Arizona. Part II: An economic analysis.
USDA For. Serv. Res. Pap. RM-127, 28 p.
Some 139 chaparral areas totaling 332,796 acres meet crown cover, slope, and managerial criteria for conversion. Using fire for conversion, 96 areas have a benefit-cost ratio greater than 1; with soil-applied herbicide, 72 areas meet that economic criterion. Other resources should be favorably affected.

BROWN, THOMAS C.,* AND RON S. BOSTER.
1974.
Effects of chaparral-to-grass conversion on wildfire suppression costs.
USDA For. Serv. Res. Pap. RM-119, 11 p.
Properly planned, carried out, and maintained, chaparral-to-grass conversions should reduce the occurrence of large, expensive wildfires. Dollar values of 'fire benefits' were calculated for 141 convertible areas in Arizona's Salt-Verde Basin. Case histories of large chaparral fires are analyzed to illustrate principles of chaparral and grass fires in the Southwest. Historical fire data were used in a predictive model, but where data were absent or insufficient, parameters were varied within specified limits. The fire benefit, though not as high as water and forage benefits resulting from conversion, is an important addition to a benefit-cost analysis. The fire benefit varies significantly from area to area because of differences in man-caused and lightning risks, and also in accessibility. While transference of dollar values to other areas is tenuous, the methodology is transferable and can be a very useful planning tool.

COLBY, MARILYN K., AND GORDON D. LEWIS.
1973.
Economics of containerized conifer seedlings.
USDA For. Serv. Res. Pap. RM-108, 7 p.
Containerized seedlings, grown in a controlled environment greenhouse, can substantially reduce time required to produce high quality seedlings, and improve seedling survival rates in outplantings. Costs per thousand surviving trees are estimated to be $460 for 2-0 bare-root stock, $441 for 2-1 potted stock, $393 for containerized greenhouse seedlings.

GARTNER, F. ROBERT,* AND KIETH E. SEVERSON.
1972.
Fee hunting in western South Dakota.
J. Range Manage. 25:234-237.
Big-game hunting fee system, now practiced by some landowners, could further cause for good range management while simultaneously maximizing economic return from rangeland.

LEWIS, GORDON D.
1975.
The benefits of vacation home developments to county governments.
p. 114-120. *In* Man, leisure, and wildlands: A complex interaction. [Proc. First Eisenhower Consortium Res. Symp., Sept. 14-19, 1975, Vail, Colo.] Eisenhower Consortium Bull. 1, 286 p.
At first, vacation home developments have relatively high benefit-cost ratios with respect to their requirements for government services, but these ratios can be reversed. County officials and land developers must provide early guidance to insure these developments are not detrimental to long-term county revenue-cost relationships.

MILLER, ROBERT L., AND FREDERIC R. LARSON.
1973.
A cost analysis of clearing a ponderosa pine watershed.

USDA For. Serv. Res. Note RM-231, 7 p.

After a commercial logging operation, cost of felling unmerchantable small trees and windrowing slash was $72.09 per acre. Costs could probably be reduced 40 percent or more by changes in treatment prescription, choice of equipment, and removal of pulpwood and firewood where markets are available.

O'CONNELL, PAUL F.
1972.

Economics of chaparral management in the Southwest. p. 260-266. *In* Watersheds in Transition Symp. [Fort Collins, Colo., June 1972] Proc. Ser. 14, 405 p. Am. Water Resour. Assoc., Urbana, Ill.

A meaningful quantitative analysis can be made of a proposed chaparral management program. On the Tonto National Forest, for example, several million dollars would be spent on outdoor recreation facilities in water-oriented and ponderosa pine areas before chaparral areas could compete.

O'CONNELL, PAUL F., AND HARRY E. BROWN.
1972.

Use of production functions to evaluate multiple use treatments on forested watersheds.
Water Resour. Res. 8:1188-1198.

Product-product functions were developed for water, timber, and herbage for five strip cutting alternatives. They indicate the supplementary, complementary, and competitive outputs obtained from a given expenditure. Outputs and costs were evaluated over a 90-year period.

O'CONNELL, PAUL F.
1972.

Valuation of timber, forage and water from National Forest lands.
Ann. Reg. Sci. 6(2):1-14.

Because some forest products are not sold in the market place, it is difficult to fit their outputs into economic models. Multi-objective alternatives for identifying relative worth include economic efficiency, regional development, and environmental quality. Economic criteria are logical for timber, forage, and consumptive water.

O'CONNELL, PAUL F.
1974.

Detailed studies in the Salt-Verde watershed.
p. 52-57. *In* 18th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1974] Proc. Ariz. Water Comm. Rep. 6, 60 p., Phoenix, Ariz.

Resume of USDA For. Serv. Res. Pap. RM-127, the status-of-our-knowledge publication by the Rocky Mountain Station. A copy of the Proceedings may be requested from the Arizona Water Commission, Phoenix.

SEVERSON, KIETH E., AND F. ROBERT GARTNER.*
1972.

Problems in commercial hunting systems: South Dakota and Texas compared.
J. Range Manage. 25:342-345.

Comparisons center around four factors: state hunting regulations, proximity of public lands, hunter demand and the game crop, and attitudes of landowners and hunters.

SUBLETTE, WERNER J.,* AND WILLIAM E. MARTIN.*
1975.

Outdoor recreation in the Salt-Verde Basin of central Arizona: Demand and value.
Ariz. Agric. Exp. Stn. Tech. Bull. 218, 41 p.

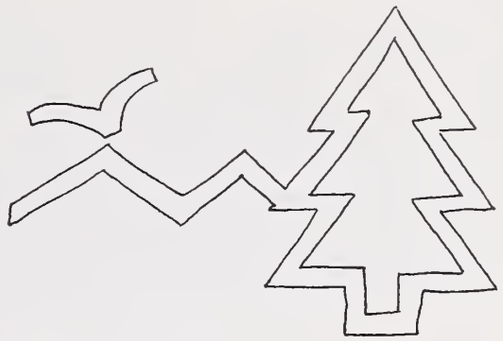
Higher net values and larger expenditures are associated with sites that have water-based recreation, considerable development at the sites, and fairly easy access. Single copy may be ordered from University of Arizona, Tucson.

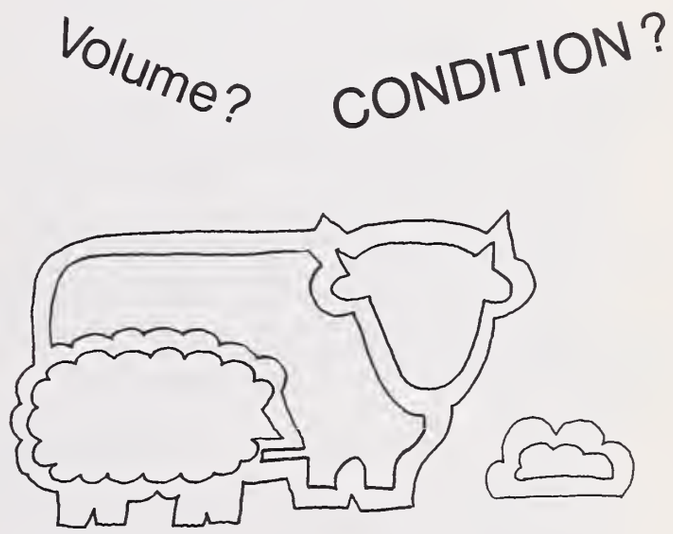
TURNER, JAMES M., AND FREDERIC R. LARSON.
1974.

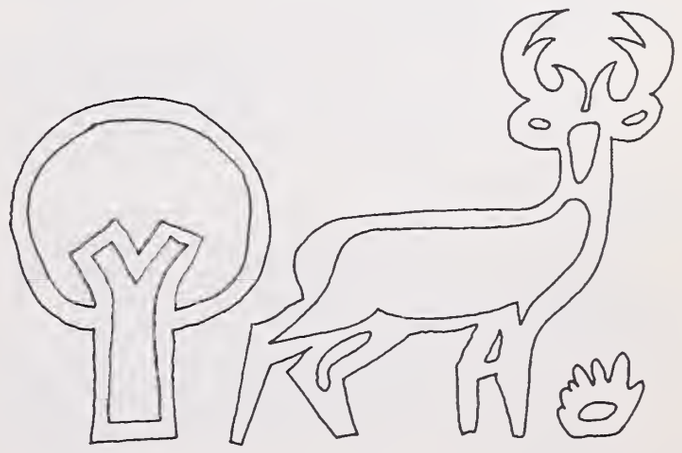
Cost analysis of experimental treatments on ponderosa pine watersheds.

USDA For. Serv. Res. Pap. RM-116, 12 p.

A regression model predicts thinning and piling costs as a function of the degree of timber basal area removed. Thinning costs are related to basal area removed noncommercially, while piling costs are related to total basal area removals including commercial logging.







WATERSHED MANAGEMENT

*Private, State or Federal cooperator

Geology

MARCUS, STEVEN R.
1973.
Geology of the Montane Zone of central Colorado--with emphasis on Manitou Park.
USDA For. Serv. Res. Pap. RM-113, 20 p.
Geologic features of four parts of the Montane Zone of central Colorado are described: (1) the Front Range, (2) the Sangre de Cristo Mountains, (3) the Spanish Peaks, and (4) the Wet Mountains. Detailed description and geologic map of the Manitou Experimental Forest are included, which provide some of the information useful in determining applicability of study results to other parts of the Zone.

Soils, Erosion

ALDON, EARL F., AND GEORGE GARCIA.
1973.
Seventeen-year sediment production from a semiarid watershed in the Southwest.
USDA For. Serv. Res. Note RM-248, 4 p.
Average annual rate of sediment production declined 71 percent in the period 1967-71 compared with the period 1956-66 on a 471-acre watershed on the Rio Puerco drainage in New Mexico. This decline was a result of an increase in plant size and litter production on the alluvial flood plain.

BOSTER, RON S., AND LESTER R. DAVIS.
1972.
Soil-loss considerations in chaparral-to-grass conversions.
p. 243-250. *In* Watersheds in Transition Symp. [Fort Collins, Colo., June 1972] Proc. Ser. 14, 405 p. Am. Water Resour. Assoc., Urbana, Ill.
Chaparral conversions can be designed with minimal initial sediment loss; vegetative conversions can save soil over time. Properly planned conversions would cause negligible to nonexistent off-site sediment impacts.

HEEDE, BURCHARD H.
1974.
Stages of development of gullies in Western United States of America.
Z. Geomorphol. 18(3):260-271.
Gully development should be recognized in terms of land form evolution. Comparison of hydraulic geometry of gullies with that of rivers suggests that the mature stage should be characterized by dynamic equilibrium. In ephemeral gullies, channel vegetation may also indicate stability.

HEEDE, BURCHARD H.
1975.
Mountain watersheds and dynamic equilibrium.
Watershed Manage. Symp., ASCE Irrig. Drain. Div. [Logan, Utah, Aug. 1975] Proc. 1975:407-420.
If considered in short timespans, landform processes may be 'dormant' between periods of change. This state of balance, called dynamic equilibrium, between landform and aggressive forces may be upset by unusual natural events, or by man's activities. Treatment effects should be considered from this viewpoint.

HEEDE, BURCHARD H.
1975.
Stages of development of gullies in the West.
p. 155-161. *In* Present and prospective technology for predicting sediment yields and sources. U.S. Dep. Agric., Agric. Res. Serv. ARS-S-40, 285 p. (Proc. Sediment-Yield Workshop, Oxford, Miss., Nov. 1972.)
Gully development should be recognized in terms of land form evolution. Comparison of hydraulic geometry of gullies with that of rivers suggests that the mature stage should be characterized by dynamic equilibrium. In ephemeral gullies, channel vegetation may also indicate stability.

HEEDE, BURCHARD H.
1975.
Watershed indicators of landform development.
p. 43-46. *In* Vol. 5, Hydrol. Water Resour. in Ariz. and the Southwest. Proc. 1975 Meet. Ariz. Sect., Am. Water Resour. Assoc. and Hydrol. Sect., Ariz. Acad. Sci., [Tempe, Ariz., Apr. 1975.]
Examples show that factors in the hydraulic geometry of streams indicate whether a watershed is in an active stage of landform development, or is in dynamic equilibrium. If geomorphology is not considered, research results could be misinterpreted.

INGEBO, PAUL A., AND ALDEN R. HIBBERT.
1974.
Runoff and erosion after brush suppression on the Natural Drainage watersheds in central Arizona.
USDA For. Serv. Res. Note RM-275, 7 p.
Herbicide treatment of sparse chaparral cover on two small catchments in central Arizona caused annual streamflow to increase 22 percent (0.36 inch) on the average. Grasses and forbs also increased, while the amount of sediment trapped at the gaging station declined.

LEAF, CHARLES F.
1974.
A model for predicting erosion and sediment yield from secondary forest road construction.
USDA For. Serv. Res. Note RM-274, 4 p.
One of the more visible and controversial environmental impacts associated with timber harvesting and development in central Colorado is road construction. This Note summarizes available data, and from this base, proposes a preliminary model for predicting an index of onsite erosion and downstream sediment yield.

STURGES, DAVID L.
1975.
Sediment transport from big sagebrush watersheds.
Watershed Manage. Symp., ASCE Irrig. Drain. Div. [Logan, Utah, Aug. 1975] Proc. 1975:728-738.
Suspended sediment and bedload transport were low on two small Wyoming watersheds. The majority of sediment movement occurred during snowmelt runoff. Movement was especially high during unique oversnow runoff events.

YAMAMOTO, TERUO, AND HENRY W. ANDERSON.*
1973.
Splash erosion related to soil erodibility and other forest soil properties in Hawaii.
Water Resour. Res. 9:336-345.
Erodibility index and bulk density jointly with saturation moisture content accounted for the highest proportion of gross splash erosion variation; organic matter content and erodibility index accounted for the highest proportion of variation in

maximum splash rate. (Request for copy may be sent to Pacific Southwest Forest and Range Exp. Stn., P.O. Box 245, Berkeley, Calif. 94701.)

Rehabilitation, Erosion Control

ALDON, EARL F.
1972.
Meander protection for stabilizing vertical gully walls. Am. Geophys. Union Trans. 53:977. (Abstr.)
Meander undercutting and subsequent sloughing of walls enlarge gullies and increase sediment loads. Describes the design of low-cost meander protection structures used on a large gully in New Mexico.

ALDON, EARL F.
1972.
Reactivating soil ripping treatments for runoff and erosion control in the Southwestern US. Ann. Arid Zone 11:154-160.
Opening old rips sealed over with sediment was as effective in controlling runoff as ripping between old rips. Re-ripping by either method reduced runoff by two-thirds. Ripping must be done carefully to avoid subterranean channel formation.

ALDON, EARL F.
1976.
Soil ripping treatments for runoff and erosion control. Fed. Inter-Agency Sediment. Conf. [Denver, Colo., Mar. 1976] Proc. 3:2-24--2-29.
Soil ripping, a form of deep, wide plowing, effectively reduces runoff and erosion from semiarid watersheds. Surface runoff was still reduced 85 percent and erosion 31 percent 3 years after treatment. Treatment effectiveness declined after 3 to 5 years depending on amounts and intensities of summer thunderstorms.

HEEDE, BURCHARD H., AND JOHN G. MUFICH.
1973.
Functional relationships and a computer program for structural gully control. J. Environ. Manage. 1:321-344.
Relations are presented between effective dam height and volume of material, cost, spacing, number of dams required, expected sediment deposits, and sediment value-treatment cost ratio. Phase I computer programs yield different design choices; Phase II selects final individual dam design and overall treatment. Programs are operational.

HEEDE, BURCHARD H., AND JOHN G. MUFICH.
1974.
Field and computer procedures for gully control by check dams. J. Environ. Manage. 2:1-49.
Computerized design of gully control by check dams eases field survey and design procedures. A minimum of data is required to design gully treatments and yield cost information. Graphical computer output shows relationships between choices by effective dam height, total cost of treatment, and benefits from expected sediment deposits.

HEEDE, BURCHARD H.
1975.
Submerged burlap strips aided rehabilitation of disturbed semiarid sites in Colorado and New Mexico. USDA For. Serv. Res. Note RM-302, 8 p.
Two planting sites with narrow submerged burlap strips showed 14 times less soil loss than control sites without burlap. Gullies and deep rills need to be reshaped to gentle swales before burlap is installed. Plant cover should become established before burlap disintegrates--in about 5 years.

Hydrology—Western Forest and Alpine Types

BROWN, HARRY E., MALCHUS B. BAKER, JR., JAMES L. ROGERS, WARREN P. CLARY, J. L. KOVNER, FREDERIC R. LARSON, CHARLES C. AVERY, AND RALPH E. CAMPBELL.
1974.
Opportunities for increasing water yields and other multiple use values on ponderosa pine forest lands. USDA For. Serv. Res. Pap. RM-129, 36 p.
Multiple use productivity is described, with special emphasis on the Beaver Creek Pilot Watershed near Flagstaff, Arizona. Changes in productivity and environmental quality are described following livestock grazing and various levels of forest thinning and clearing. Preliminary analytical procedures allow the user to estimate the tradeoffs in production and environmental quality.

CLARY, WARREN P., MALCHUS B. BAKER, JR., PAUL F. O'CONNELL, THOMAS N. JOHNSEN, JR.,* AND RALPH E. CAMPBELL.
1974.
Effects of pinyon-juniper removal on natural resource products and uses in Arizona. USDA For. Serv. Res. Pap. RM-128, 28 p.
Describes results of pilot treatments to increase yields of water and forage by removing pinyon and juniper trees. Herbicide treatments are more effective than mechanical removal of trees, but even on the more successful projects, costs and benefits are about even. Effects on other resources are about neutral.

FRANK, ERNEST C.
1973.
Snow amount in relation to streamflow and herbage production in western Colorado. J. Range Manage. 26:32-34.
A 10 percent increase in peak snowpack, due to cloud seeding or natural events, is partly returned as runoff but has little, if any, immediate effect on the productivity and use of mountain grasslands.

FRANK, ERNEST C., HARRY E. BROWN, AND J. R. THOMPSON.
1975.
Hydrology of Black Mesa watersheds, western Colorado. USDA For. Serv. Gen. Tech. Rep. RM-13, 11 p.
Eleven years of runoff and suspended sediment data show no relationship to bare soil intercept, which decreased although grazing utilized an average of 40 percent of the grass. By current classification schemes, sediment yields indicate very minor amounts of geologic erosion.

GARY, HOWARD L.
1972.
Rime contributes to water balance in high-elevation aspen forests. J. For. 70:93-97.
The water contribution from rime for each of two winters studied was about 1 inch.

GARY, HOWARD L.
1974.
Growth of Engelmann spruce *(Picea engelmannii)* unaffected by increased snowpack. Arct. and Alp. Res. 6:29-36.
Comparison of radial growth of spruce trees in forest interior (shallow snowpack) and near the edge of a burn (deep snowpack) suggest that weather modification to increase snowfall in the Southwest will have little detrimental effect on annual or long-term tree growth.

GARY, HOWARD L.
1974.

Snow accumulation and snowmelt as influenced by a small clearing in a lodgepole pine forest.
Water Resour. Res. 10:348-353.

The clearing affected the distribution of snow over the area but not the total snow water equivalent. Melt rates in the clearing were about twice those in the interior forest. Near the middle of the melt season the clearing contained 12 percent less snow water equivalent than the forest.

GARY, HOWARD L.
1974.

Snow accumulation and melt along borders of a strip cut in New Mexico.
USDA For. Serv. Res. Note RM-279, 8 p.

Snowfall amounts were similar along the sunny and shady borders of an east-west clearcut strip, but greater than in the adjacent forest. Snow disappeared 5 to 6 weeks earlier along the sunny border than along the shady border or forest interior.

GARY, HOWARD L.
1975.

Watershed management problems and opportunities for the Colorado Front Range ponderosa pine zone: The status of our knowledge.
USDA For. Serv. Res. Pap. RM-139, 32 p.

Soils in the region were developed from granites, are relatively infertile, and erode easily after abuse. Water yields are relatively low. Plot studies corroborated with large-scale studies on timbered and grazed areas have provided guidelines for maintaining satisfactory watershed conditions.

HAEFFNER, ARDEN D., AND CHARLES F. LEAF.
1973.

Areal snow cover observations in the central Rockies, Colorado.
USDA For. Serv. Gen. Tech. Rep. RM-5, 15 p.

Photographic records of areal snow cover depletion during the 1964-71 snowmelt seasons in the Fraser Experimental Forest, and in the Park Range from 1966-71, are summarized. Included are detailed estimates of snow cover extent on more than 90 hydrologic subunits which comprise the six watersheds photographed. Applications of these data in streamflow forecasting, water balance analyses, and snow cover duration are suggested.

HEEDE, BURCHARD H.
1972.

Influences of a forest on the hydraulic geometry of two mountain streams.
Water Resour. Bull. 8:523-530.

Steps provided by logs fallen across the channel added to flow energy reduction. Implications for forest management are that sanitation cuts would not be permissible where a stream is in dynamic equilibrium and bed material movement should be minimized.

HEEDE, BURCHARD H.
1972.

Flow and channel characteristics of two high mountain streams.
USDA For. Serv. Res. Pap. RM-96, 12 p.

Logs fallen across the channels provided steps, adding to flow energy reduction. The streams required additional gravel bars to adjust to slope. More bars formed when fewer numbers of logs were available. The streams had attained dynamic equilibrium. Removal of dead and dying trees (sanitation cutting) would not be permissible where such equilibrium exists and bed material movement should be minimized.

HOOVER, MARVIN D.
1975.

Watershed management in lodgepole pine ecosystems. p. 569-580. *In* Manage. Lodgepole Pine Ecosyst. Symp. [Pullman, Wash., Oct. 1973] Proc., 2 vols. David M. Baumgartner, ed. Wash. State Univ., Pullman.

The proportion of water yield to precipitation is high because of cold climate, short growing season, and accumulation of an overwinter snowpack. Water quality is excellent but subject to damage by road construction. Yields can be increased, but the larger amounts flow off during the natural high-water season.

LEAF, CHARLES F., AND JACOB L. KOVNER.
1972.

Sampling requirements for areal water equivalent estimates in forested subalpine watersheds.
Water Resour. Res. 8:713-716.

Guidelines developed for sampling mountain snowpacks on an areal basis were: (1) sampling zones should be stratified by elevation, the sampling in each zone being proportional, and (2) sampling points should be widely spaced over each zone, two duplicate measurements at most being made at a location.

LEAF, CHARLES F., AND GLEN E. BRINK.
1972.

Simulating effects of harvest cutting on snowmelt in Colorado subalpine forest.
p. 191-196. *In* Watersheds in Transition Symp. [Fort Collins, Colo., June 1972] Proc. Ser. 14, 405 p. Am. Water Resour. Assoc., Urbana, Ill.

Results from the model agree in general with empirical knowledge, which indicates the model can be developed into a useful tool for simulating alternatives to help determine which harvest cutting systems will optimize patterns of snowmelt.

LEAF, CHARLES F., AND GLEN E. BRINK.
1972.

Simulating watershed management practices in Colorado subalpine forest.
ASCE Annu. Natl. Environ. Eng. Meet. [Houston, Tex., Oct. 1972] Prepr. 1840, 26 p.

A dynamic model is being developed for simulating the hydrologic behavior of subalpine watersheds. Preliminary results show the probable directions and magnitudes of hydrologic changes resulting from timber harvesting and weather modification.

LEAF, CHARLES F., AND GLEN E. BRINK.
1972.

Annual streamflow summaries from four subalpine watersheds in Colorado.
USDA For. Serv. Gen. Tech. Rep. RM-1, 24 p.

Streamflow runoff summaries are presented for four experimental watersheds near Fraser and Steamboat Springs, Colorado. Interval of published record varies from 1943-71 at Fraser to 1967-71 at Steamboat Springs.

LEAF, CHARLES F., AND GLEN E. BRINK.
1973.

Computer simulation of snowmelt within a Colorado subalpine watershed.
USDA For. Serv. Res. Pap. RM-99, 22 p.

A dynamic model simulates snowmelt for all combinations of aspect, slope, elevation, and forest cover composition and density. The model simulates winter snow accumulation, energy balance, snowpack condition, and resultant melt.

LEAF, CHARLES F., AND GLEN E. BRINK.
1973.

Hydrologic simulation model of Colorado subalpine forest.
USDA For. Serv. Res. Pap. RM-107, 23 p.

Designed to determine probable hydrologic changes resulting from watershed management, the model simulates total water balance on a year-round basis and compiles results from individual hydrologic response units into a 'composite overview' of an entire basin. Results are summarized for an 8-year period on a 667-acre experimental watershed.

LEAF, CHARLES F.
1974.

More water from mountain watersheds.

Colo. Rancher Farmer 28(7):11-12.

A feature article that tells how carefully designed patch cutting in lodgepole pine and spruce-fir forests can increase water yields.

LEAF, CHARLES F., AND GLEN E. BRINK.

1975.

Land use simulation model of the subalpine coniferous forest zone.

USDA For. Serv. Res. Pap. RM-135, 42 p.

A dynamic model simulates the short- and long-term hydrologic impacts of combinations of timber harvesting and weather modification to develop management strategies for planning intervals which can vary from a few years to the rotation age of subalpine forests (120 years and longer).

LEAF, CHARLES F.

1975.

Watershed management in the Rocky Mountain subalpine zone: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-137, 31 p.

Reviews field studies on the effects of watershed management practices on snow accumulation, melt, and subsequent runoff, and simulation models to predict the hydrologic impacts of timber harvesting and weather modification. Highlights research needs, and summarizes guidelines for implementing watershed management principles in land use planning.

LEAF, CHARLES F.

1975.

Watershed management in the central and southern Rocky Mountains: A summary of the status of our knowledge by vegetation types.

USDA For. Serv. Res. Pap. RM-142, 28 p.

Summarizes a series of comprehensive reports on watershed management in five major vegetation zones: (1) the coniferous forest subalpine zone; (2) the Front Range ponderosa pine zone; (3) the Black Hills ponderosa pine zone; (4) the alpine zone; and (5) the big sagebrush zone. Includes what is known about the hydrology of these lands, what hydrologic principles are important for multiresource management, and what additional information is needed for each vegetation type. (Available from Superintendent of Documents, Stock No. GPO 001-001-00398.)

MARTINELLI, M., JR.

1975.

Water-yield improvement from alpine areas: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-138, 16 p.

Snowpack management can be an effective means of improving water yields from the already productive alpine type. Snow accumulates in the lee of terrain breaks, and fences upwind of natural accumulation areas effectively trap additional snow. Snowfences can also control blowing and drifting snow on highways and in avalanche-prone areas.

ORR, HOWARD K.

1972.

Throughfall and stemflow relationships in second-growth ponderosa pine in the Black Hills.

USDA For. Serv. Res. Note RM-210, 7 p.

Rainfall alone accounted for 85 to 99 percent of throughfall variation. Stemflow was also primarily dependent on rainfall. Results further demonstrate adjustment of throughfall for mean canopy density, adjustment of stemflow for tree d.b.h., and combination of these relationships to estimate net rainfall for different stand densities.

ORR, HOWARD K., AND TONY VANDER HEIDE.*

1973.

Water yield characteristics of three small watersheds in the Black Hills of South Dakota.

USDA For. Serv. Res. Pap. RM-100, 8 p.

Three small forested watersheds in the northeastern Black Hills have yielded surface runoff equivalent to 25, 27, and 23 percent of average annual precipitation, water years 1964-69, inclusive. Net differences between precipitation and outflow closely approximate yearly evapotranspiration.

ORR, HOWARD K.

1973.

The Black Hills (South Dakota) flood of June 1972: Impacts and implications.

USDA For. Serv. Gen. Tech. Rep. RM-2, 12 p.

Rains of 12 inches or more fell in 6 hours; resulting flash floods exacted a disastrous toll in human life and property. Rainfall and discharge were so great that recurrence intervals are presented in multiples of the estimated 50- or 100-year event. Quick runoff was produced regardless of hydrologic condition.

ORR, HOWARD K.

1975.

Watershed management in the Black Hills: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-141, 12 p.

Climate, geology, soils, vegetation, and water yields are briefly described, followed by a review and discussion of watershed management research and problems unique to the Black Hills. Research needs with respect to water quality, data collection, and model development are highlighted.

RICH, LOWELL R.

1972.

Managing a ponderosa pine forest to increase water yield.

Water Resour. Res. 8:422-428.

An improved type of timber harvest and subsequent management were applied to determine how it influenced water and sediment yields, wildlife, and scenic values as well as the long-term effect on timber. Water yields improved significantly, with no measurable sediment trapped above the weir.

RICH, LOWELL R., AND J. R. THOMPSON.

1974.

Watershed management in Arizona's mixed conifer forests: The status of our knowledge.

USDA For. Serv. Res. Pap. RM-130, 15 p.

Removing mixed conifer forest vegetation has increased water yields approximately in proportion to the percent of the area in cleared openings. When fitted to the timber-stand structure, patchcutting is compatible with recommended mixed conifer silviculture, beneficial to wildlife, and esthetically pleasing.

SOLOMON, RHEY M.,* PETER F. FFOLLIOTT,* MALCHUS B. BAKER, JR., GERALD J. GOTTFRIED, AND J. R. THOMPSON.

1975.

Snowmelt runoff efficiencies on Arizona watersheds.

Ariz. Agric. Exp. Stn. Res. Rep. 274, 50 p.

Documents efficiencies for several experimental watersheds in different vegetation zones. Tentative regression equations were developed relating snowpack runoff efficiencies to inventory-prediction variables. Timing of precipitation during the accumulation-melt period is of prime significance.

THOMPSON, J. R.

1974.

Energy budget measurements over three cover types in eastern Arizona.

Water Resour. Res. 10:1045-1048.

Energy budget measurements were used to determine seasonal patterns of the ratio of evapotranspiration (ET) to net radiation (Rn).

THOMPSON, J. R.

1974.

Water yield research in Arizona's mixed conifer forests.

p. 15-17. *In* 18th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1974] Proc. Ariz. Water Comm. Rep. 6, 60 p., Phoenix, Ariz.

Resume of USDA For. Serv. Res. Pap. RM-130, the status-of-our-knowledge publication by the Rocky Mountain Station. A copy of the Proceedings may be requested from the Arizona Water Commission, Phoenix.

THOMPSON, J. ROBERT.
1975.
Energy budgets for three small plots--substantiation of Priestley and Taylor's large-scale evaporation parameter.
J. Appl. Meteorol. 14(7):1399-1401.
Energy balance data collected in the White Mountains of Arizona indicate the variability in alpha for unsaturated conditions, and seem to verify a constant value of 1.26 for saturated conditions. The 'index of aridity' (alpha/1.26), though not entirely logical for small-scale use, also seems to substantiate the large-scale parameter.

YAMAMOTO, TERUO, AND HOWARD K. ORR.
1972.
Morphometry of three small watersheds, Black Hills, South Dakota, and some hydrologic implications.
USDA For. Serv. Res. Pap. RM-93, 15 p.
Morphometry and hydrologic character are analyzed in terms of elementary length dimensions, nondimensional expressions, and similitude concepts. It is theorized that these form elements (1) exert primary control over volume yield and peak flows, and (2) are better indicators of relative volume yields and peak flows than is surface area.

Hydrology—Shrub and Grass Types

HIBBERT, ALDEN R., EDWIN A. DAVIS, AND DAVID G. SCHOLL.
1974.
Chaparral conversion potential in Arizona. Part I: Water yield response and effects on other resources.
USDA For. Serv. Res. Pap. RM-126, 36 p.
On favorable areas, conversion to grass reduces fire hazard and increases water yield and forage for livestock. If treatment areas are small, the edge effect created will enhance the environment for wildlife. Control methods effective in Arizona are rootplowing, prescribed burning, chemicals, and chemicals in combination with the others.

HIBBERT, ALDEN R.
1976.
Percolation and streamflow in range and forest lands.
p. 61-72. *In* Watershed management on range and forest lands. Proc. Fifth Workshop of U.S./Aust. Rangelands Panel, Boise, Idaho, June 1975.
Differences in surface and subsurface hydrology on range and forest lands stem largely from differences in climate, soils, vegetation, and topography. Infiltration, or lack of it, is a critical process in the hydrology of these lands, expecially as related to flooding characteristics.

INGEBO, PAUL A.
1972.
Converting chaparral to grass to increase streamflow.
p. 181-192. *In* Hydrology and water resources in Arizona and the Southwest. Ariz. Sect., Am. Water Resour. Assoc., and Hydrol. Sect., Ariz. Acad. Sci. [Prescott, Ariz., May 1972] Proc. v. 2, 492 p.
Chemical treatment of one of a pair of calibrated watersheds increased average annual runoff 0.61 inch. Pelleted funuron was applied to 15 percent of the area along stream channels. Streamflow was intermittent before treatment in 1967, but has been continuous since.

PASE, CHARLES P.
1972.
Litter production from oak-mountainmahogany chaparral in central Arizona.
USDA For. Serv. Res. Note RM-214, 7 p.
Annual litter fall of shrub live oak was 192 g/sq m crown area on southerly slopes, and 138 g on northerly slopes. For the chaparral community as a whole, southerly aspects produced 193 g/sq m crown areas and northerly aspects, 215 g. Most litter fell during late spring and early summer, least in fall and early winter. Forest floor varied from 9.2 to 27.1 metric tons per ha. Maximum water retained against free drainage was 4.8 mm under shrub live oak and 5.1 mm under Pringle manzanita.

STURGES, DAVID L.
1973.
Soil moisture response to spraying big sagebrush the year of treatment.
J. Range Manage. 26:444-447.
Spraying with 2,4-D in Wyoming reduced soil moisture loss 24 percent between June 24, the treatment date, and September 30. All of the reduction accrued by August 4, during active growth; 83 percent of the reduction was in soil 2 to 6 ft deep.

STURGES, DAVID L.
1975.
Hydrologic relations on undisturbed and converted big sagebrush lands: The status of our knowledge.
USDA For. Serv. Res. Pap. RM-140, 23 p.
Climate, soils, vegetation, snow accumulation, and water yields are described, followed by a review of how management practices alter vegetative composition and the hydrologic regime. Potential hydrologic benefits from managing blowing snow in the big sagebrush type are outlined and research needs are highlighted.

STURGES, DAVID L.
1975.
Oversnow runoff events affect streamflow and water quality.
p. 105-117. *In* Snow Manage. on Great Plains Symp. [Bismarck, N. Dak., July 1975] Proc. Great Plains Agric. Counc. Publ. 73, 186 p.
Oversnow flow, which develops when snow melts rapidly early in the melt season, increases maximum flow rates three to five times, and runoff as a percentage of winter precipitation four times. Suspended sediment concentrations are also much higher.

Hydrology—Riparian and Phreatophyte Types

HORTON, JEROME S.
1973.
Evapotranspiration and water research as related to riparian and phreatophyte management: An abstract bibliography.
U.S. Dep. Agric. Misc. Publ. 1234, 192 p.
Over 700 entries are indexed and cross referenced. Purpose of abstract bibliography is to bring together published information that will help land managers and research workers to (1) evaluate relations of revegetation to water loss, and (2) estimate probable effect on water yield of manipulating vegetation.

HORTON, JEROME S., AND C. J. CAMPBELL.
1974.
Management of phreatophyte and riparian vegetation for maximum multiple use values.
USDA For. Serv. Res. Pap. RM-117, 23 p.
Summarizes the status of our knowledge about environmental relations of vegetation along water courses in the southwestern United States, and impacts of vegetation management to reduce evapotranspiration on other resource values. Suggests approaches to management of moist-site areas by zones based primarily on water table depth, elevation, and tree species.

Water Quality

DAVIS, E. A., AND P. A. INGEBO.
1973.
Picloram movement from a chaparral watershed.
Water Resour. Res. 9:1304-1313.
An estimated 4.5 percent of picloram, soil-applied as pellets in a brush-control treatment, was lost to stream water. Maximum concentrations, 370 parts per billion, were measured after heavy rainfall. Picloram was no longer detected after 14 months and 40 inches accumulated rainfall.

PATTON, DAVID R.
1973.
A literature review of timber-harvesting effects on stream temperatures: Research needs for the Southwest.
USDA For. Serv. Res. Note RM-249, 4 p.
Water temperature affects fish by changing their metabolic rate, changing oxygen content of water, influencing hatching and development time, and influencing migration. Creating a more open forest in the water-producing zone can change water temperature in shallow, low-volume streams. Research is needed on how timber harvesting affects water temperature to produce guidelines to meet Federal Water Pollution Control standards for cold-water fish.

Avalanches, Snow Physics

JUDSON, ARTHUR, AND BERNARD J. ERICKSON.
1973.
Predicting avalanche intensity from weather data: A statistical analysis.
USDA For. Serv. Res. Pap. RM-112, 12 p.
A two-parameter storm index and a discriminant function model predict the likelihood of avalanches in Colorado's Front Range. The storm index utilizes precipitation intensity modified by windspeed. The discriminant function model uses maximum 3-hour precipitation intensities, windspeed resolved to an optimum direction, and negative temperature departures from 20 degrees F.

JUDSON, ARTHUR.
1975.
Avalanche warnings: Content and dissemination.
USDA For. Serv. Res. Note RM-291, 8 p.
Snow avalanche warnings alert the public to unusually dangerous avalanche conditions. An effective warning message conveys a sense of urgency, and should have an official and authoritative source. Warnings are transmitted through the National Weather Service's communications network to the media and public.

MARTINELLI, M., JR.
1972.
Simulated sonic boom as an avalanche trigger.
USDA For. Serv. Res. Note RM-224, 7 p.
A linear array of detonating cord was used to simulate a sonic boom. The boom from such charges was directed toward the fracture zone of a small avalanche path where the snow was unstable, as indicated by natural avalanches in the area. On three of four tests, avalanches were released by a boom of 12 pounds per square foot (60 kg f/sq. m.) overpressure after withstanding lesser booms. One of the avalanches had a fracture face 8 feet 11 inches (272 cm) deep.

MARTINELLI, M., JR.
1973.
Avalanche.
p. 115-117, *In* Yearbook of Science and Technology, 1972. 468 p. McGraw-Hill, N.Y.
Recent avalanche research has focused on mechanical properties of snow on the ground, and how it fails just prior to an avalanche. Snow, weather, and avalanche history data are now used to determine when to use artillery to 'shoot down' avalanches along highways.

MARTINELLI, M., JR.
1974.
Snow avalanche sites: Their identification and evaluation.
U. S. Dep. Agric. Agric. Inf. Bull. 360, 27 p.
Avalanches in mountain areas threaten lives and damage property. Persons who plan to build new facilities or expand or relocate old ones should know how to recognize potentially dangerous sites. This bulletin describes and illustrates avalanche-prone areas and recommends a checklist to help evaluate field evidence of avalanche activity. (Available from Superintendent of Documents, Stock No. GPO 0100-03303, 75 cents.)

PERLA, R. I.
1972.
Generalization of Haefeli's creep-angle analysis.
J. Glaciol. 11:447-450.
A generalization of the creep angle, called the deformation-rate coefficient, is derived by replacing geometrical arguments with continuum mechanics. Once the coefficient is found from *in situ* measurements, the stress field of the slab can be determined from a set of hyperbolic partial differential equations.

PERLA, R. I.
1973.
Hyperbolic stress equations for compressible slabs.
Int. J. Non-Linear Mech. 8:253-259.
A constitutive law, chosen to model isotropic compressible slabs, is specialized for plane deformation and then substituted into the equations of motion. The resulting system is quasi-linear hyperbolic.

PERLA, R. I. (COMPILER).
1973.
Advances in North American avalanche technology: 1972 symposium.
USDA For. Serv. Gen. Tech. Rep. RM-3, 54 p.
Seven technical presentations, made in connection with the USDA Forest Service National Avalanche Training Program, discuss acoustic signals emitted by snow under stress, aspects of snow slab mechanics, use of explosives, and problems of avalanche dynamics.

SOMMERFELD, R. A.
1973.
Statistical problems in snow mechanics.
p. 29-36, *In* Advances in North American avalanche technology: 1972 symposium. USDA For. Serv. Gen. Tech. Rep. RM-3, 54 p.
For density measurements, the mean and standard deviation are meaningful parameters. For strength data, the mean is not very useful; extreme-value statistics should be used. Weibull statistics appear appropriate for evaluating tensile strength data, thread bundle statistics of Daniels for shear strength.

SOMMERFELD, RICHARD A.
1973.
The bulk tensile strength of snow.
Am. Geophys. Union Trans. 54:460. (Abstr.)
Tensile strengths of various snow types, from newly fallen to highly metamorphosed, were extrapolated to large volumes by fitting to Weibull distributions. These large-volume strengths were functions of both snow density and type.

SOMMERFELD, R. A.
1974.
A Weibull prediction of the tensile strength-volume relationship of snow.
J. Geophys. Res. 79:3353-3356.
A comparison of previous work and data presented here show

that the brittle tensile strength of snow varies with sample volume. If the hypothesis that snow has a predictable minimum tensile strength and that volumes larger than 1 cubic meter exhibit the minimum strength could be verified, predictions of slab failure might be greatly simplified.

SOMMERFELD, R. A.
1975.
Continuous measurements of deformations on an avalanche slope.
p. 293-297. *In* Snow mechanics--Symposium [Grindelwald, Switz., Apr. 1974] IAHS-AISH Publ. 114.
Deformation measurements are necessary to test methods of calculating stresses in snow slabs. The instruments described can be embedded in the slab and continuously monitor the positions of points in the slab without disturbance.

U.S. DEPARTMENT OF AGRICULTURE. FOREST SERVICE.
1975.
Avalanche protection in Switzerland. [Lawinenschutz in der Schweiz, translated by U.S. Army, CRREL].
USDA For. Serv. Gen. Tech. Rep. RM-9, 168 p.
This translation of a collection of 16 articles by Swiss avalanche experts summarizes the current state-of-the-art of structural control of avalanches in Europe. It includes chapters on avalanche formation and damage, supporting structures, deflecting and retarding structures, and political aspects of controls.

WILLIAMS, KNOX.
1972.
Avalanches in our western mountains: What are we doing about them.
Weatherwise 25:220-227.
Describes some tragic avalanches in the Cascades, then covers special weather forecasts and avalanche warnings, the National Avalanche School, protective structures and avalanche control, and avalanche zoning.

WILLIAMS, KNOX.
1975.
The snowy torrents: Avalanche accidents in the United States 1967-71.
USDA For. Serv. Gen. Tech. Rep. RM-8, 190 p.
This compilation of 76 avalanche accident reports teaches by example, both good and bad. Commentaries will help those who spend time in the mountains in winter how to avoid getting caught in an avalanche, or if caught, how to survive. (Available from Superintendent of Documents, Stock No. GPO 001-000-00399.)

WILLIAMS, KNOX.
1975.
Avalanche fatalities in the United States, 1950-75.
USDA For. Serv. Res. Note RM-300, 4 p.
Snow avalanches have caused 147 deaths over the last 25 years--an average of 6 per year. In the last 5 years, however, the death rate has doubled. Nearly three-fourths of all avalanche victims are recreationists.

Snow Fences, Blowing Snow

GARY, HOWARD L.
1975.
Airflow patterns and snow accumulation in a forest clearing.
West. Snow Conf. [Coronado, Calif., Apr. 1975] Proc. 43:106-113.
Comparisons before and after clearing a narrow opening in a lodgepole pine forest suggest that clearings may become saturated similar to snowfence systems, and that the accumulation pattern reflects primarily wind drift of falling snow rather than subsequent erosion and redeposition.

MARTINELLI, M., JR.
1973.
Snow-fence experiments in alpine areas.
J. Glaciol. 12:291-303.
Fences most successfully augmented natural snow accumulation at sites with level or gently sloping terrain downwind. Between 15 and 30 meters of 3-meter-tall fence was needed to produce an extra 1000 cubic meters of water equivalent in the snowfields at the beginning of the melt season.

MARTINELLI, M., JR.
1973.
Snow fences for influencing snow accumulation.
p. 1394-1398. *In* The role of snow and ice in hydrology. Symp. on Measurement and Forecasting (WMO) [Banff, Alberta, Can., Sept. 1972] Proc. 2 vols.
Efficiency of collecting snow fences is affected by height, density, and length of fence, bottom gap, length and maximum depth of lee drift, cumulative effect of tandem fences, tilting, terrain, and contributing distance.

SCHMIDT, R. A., JR.
1972.
Sublimation of wind transported snow--a model.
USDA For. Serv. Res. Pap. RM-90, 24 p.
Sublimation from blowing snow is estimated from the balance of heat and mass transfer on a volume of air and nonuniform ice particles. Size and the distribution of sizes are important particle factors, but fragmented and abraided shapes appear to increase sublimation only slightly above the estimate for spherical particles. Humidity and temperature are the overriding environmental factors, but atmospheric pressure and solar radiation are also important. The effect of turbulence on convection around the particles does not appear important in view of the small particle sizes encountered. Rather, turbulent transfer determines the snow concentration profile, and the gradients of heat and water vapor necessary to balance the sublimation process.

TABLER, RONALD D.
1973.
Snow fences improve highway safety.
Pub. Works 104(8):74-75.
Fence design is based on the distance a blowing snow particle can travel before it sublimates. Carefully located 12-foot-tall fences keep drifts off Interstate 80, and improve visibility.

TABLER, RONALD D.
1973.
New snow fence design controls drifts, improves visibility, reduces road ice.
Annu. Transp. Eng. Conf. [Denver, Colo., Feb. 1973] Proc. 46:16-27.
Research results were used to determine best height, spacing, and location of fences in an extensive snow fence system on Interstate 80 in southeastern Wyoming. In addition to exceptionally effective drift control, ice formation was reduced and visibility improved dramatically.

TABLER, RONALD D.
1973.
Evaporation losses of windblown snow, and the potential for recovery.
West. Snow Conf. [Grand Junction, Colo., Apr. 1973] Proc. 41:75-79.
Losses are defined in terms of transport distance, the average distance a snow particle must travel before completely evaporating. Extensive snow fence systems designed to protect Interstate 80 in southeastern Wyoming by trapping blowing snow esablish the validity of the concept.

TABLER, RONALD D., AND R. A. SCHMIDT.
1973.
Weather conditions that determine snow transport distances at a site in Wyoming.
p. 118-126. *In* The role of snow and ice in hydrology. Symp. on Properties and Processes (Unesco) [Banff, Alberta, Can., Sept. 1972] Proc. 2 vols.
Measurements of total insolation and air temperature and relative humidity during all 1970-71 winter drifting events indicate average transport distances of 460 and 900 m for particle diameters of 0.010 and 0.015 cm, respectively.

TABLER, RONALD D.
1974.
New engineering criteria for snow fence systems.
Transp. Res. Rec. 506, p. 65-78. NAS-NRC, Wash., D.C.
Amount of blowing snow arriving at a site is estimated from an equation relating snow transfer coefficient, transport distance, and precipitation received over the contributing distance. Height and number of fences to provide required capacity are then computed. The system effectively prevents drifts, improves visibility, and reduces road ice.

TABLER, RONALD D.
1975.
Estimating the transport and evaporation of blowing snow.
p. 85-104. *In* Snow Manage. on Great Plains Symp. [Bismarck, N. Dak., July 1975] Proc. Great Plains Agric. Counc. Publ. 73, 186 p.
In an empirical process, the distance an average-sized snow particle can travel before it completely evaporates (sublimates) is calculated to account for the net effect of intricate relationships among temperature, humidity, radiant energy, and abrasive forces. Results agree well with measured snow accumulations in southeastern Wyoming.

TABLER, RONALD D.
1975.
Predicting profiles of snowdrifts in topographic catchments.
West. Snow Conf. [Coronado, Calif., Apr. 1975] Proc. 43:87-97.
A regression model requires only terrain data to estimate snowdrift profiles. Drift slopes are influenced by the terrain from 150 feet upwind to an equal distance downwind of the catchment lip. Applications in addition to highway design include reshaping strip-mined terrain to maximize onsite snow retention.

WYOMING HIGHWAY DEPARTMENT.
1972.
Fencing parries winter's thrusts.
The Highwayman 22(1):12-14.
First-year results of a cooperative agreement between the Wyoming Highway Department and the Rocky Mountain Forest and Range Experiment Station show the snow-fence system designed by R. D. Tabler and R. A. Schmidt, Jr., of the Station, to protect Interstate 80 in Wyoming was highly effective. Several miles of fence, most of it 12 feet high, greatly reduced plowing requirements and dramatically improved visibility.

Measurement Techniques, Instrumentation

CAMPBELL, C. J., AND CHARLES P. PASE.
1972.
Pressure bomb measures changes in moisture stress of birchleaf mountainmahogany after partial crown removal.
USDA For. Serv. Res. Note RM-221, 4 p.
The pressure-bomb technique detected highly significant changes in plant-moisture stress of mountainmahogany following 41 percent or more leaf-mass removal, but no significant reductions in stress when leaf mass removed was 36 percent or less.

CAMPBELL, C. J.
1973.
Pressure bomb measurements indicate water availability in a southwestern riparian community.
USDA For. Serv. Res. Note RM-246, 4 p.
The Scholander pressure-bomb technique detected differences in plant moisture stress between and among species, thereby delineating areas of high or low potential evapotranspiration within a riparian zone.

GARY, HOWARD L.
1976.
A tripod mount to aid in lifting heavy objects.
USDA For. Serv. Res. Note RM-305, 2 p.
Describes an easily constructed tripod that can be mounted on legs of varying length. When equipped with a sheave or block and tackle, the mount can accommodate a wide variety of hoisting needs.

HAEFFNER, ARDEN D., AND A. H. BARNES.*
1972.
Photogrammetric determinations of snow cover extent from uncontrolled aerial photographs.
Am. Soc. Photogramm. [Columbus, Ohio, Oct. 1972] ASP Tech. Sess. Proc., p. 319-340.
Overlapping, vertical aerial photos provide sufficient information for determining extent of snow cover in a small open area of mountainous terrain where accurate ground control is not available. Index measurements can be extrapolated to a much larger drainage.

HEEDE, BURCHARD H.
1974.
Velocity-head rod and current meter use in a boulder-strewn mountain stream.
USDA For. Serv. Res. Note RM-271, 4 p.
The velocity-head rod should not be used in boulder-strewn mountain streams unless the gaged section can be modified to obtain uniform flow. The one-point current-meter method will suffice for most operational purposes.

JAIRELL, ROBERT L.
1975.
A sturdy probe for measuring deep snowdrifts.
USDA For. Serv. Res. Note RM-301, 3 p.
Sections of hexagonal aluminum rod joined with pump couplings form a rigid probe that does not bend while penetrating ice layers. Bit design is important.

JAIRELL, ROBERT L.
1975.
An improved recording gage for blowing snow.
Water Resour. Res. 11(5):674-680.
The most important improvement is the efficient turntable design which allows the precipitation gage to be independent of the snow trap. The result is a high-quality chart record. Principal advantages include simplicity, low cost, and suitability for operation in remote areas lacking electrical power.

JOHNSON, KENDALL L., AND RONALD D. TABLER.
1973.
An enclosed weir for small streams in snow country.
USDA For Serv. Res. Note RM-238, 8 p.
An enclosed sharp-crested V-notch weir provides trouble-free winter operation. A multiplate pipe arch with closed ends is fitted over an independent cutoff wall; the instrument shelter is mounted on the arch over a stilling well. Compared to conventional design, construction time was reduced 50 percent, total costs 40 percent.

JOHNSON, KENDALL L.

1974.

A sleeved pit gage for summer precipitation.
USDA For. Serv. Res. Note RM-256, 3 p.

Performance of a pit gage was greatly improved by using a 5-gallon cream can as a sleeve. Four years of experience have shown the improved pit gage to be nearly ideal for keeping the gage vertical and free of soil, and facilitating quick removal and reinsertion of the gages for periodic weighing.

LARSON, FREDERIC R., PETER F. FFOLLIOTT,* AND KARL E. MOESSNER.*

1974.

Using aerial measurements of forest overstory and topography to estimate peak snowpack.
USDA For. Serv. Res. Note RM-267, 4 p.

Where slope steepness and aspect vary widely and forest overstory size and density classes are intermixed, only topographic attributes need be measured. All of the tested photo scales were satisfactory. On nearly level sites where size and density classes are homogeneous, forest overstory attributes also must be measured.

LARSON, FREDERIC R.

1974.

Formulating conversion tables for stick-measure of Sacramento precipitation storage gages.
USDA For. Serv. Res. Note RM-276, 2 p.

These gages are usually built to specifications by local sheet metal companies where quality control is limited. This Note presents two mathematical models for estimating precipitation in locally constructed gages. A calibration technique is also described.

MARTINELLI, M., JR.

1972.

Take the plunge.
Ski Area Manage. 11(1):26-28.

The rammsonde is a simple, reliable device for measuring snow compaction or hardness. It can help the ski area manager evaluate trail maintenance techniques and results.

OZMENT, ARNOLD D.

1975.

Development and testing of a laser rain gage.
p. 185-190. *In* Vol. 5, Hydrol. Water Resour. in Ariz. and the Southwest. Proc. 1975 Meet. Ariz. Sect., Am. Water Resour. Assoc. and Hydrol. Sect., Ariz. Acad. Sci., [Tempe, Ariz., Apr. 1975.]

Precipitation is measured by scattering a beam from a helium-neon laser. Although calibration is still a problem, the laser gage does not disturb windflow, gives instantaneous rainfall rates, and can effectively sample large areas. Pairs of beams could measure interception.

SCHMIDT, R. A.

1975.

Analog temperature records from a linearized thermistor network.
USDA For. Serv. Res. Note RM-286, 4 p.

To overcome the inherent disadvantage of nonlinear output, a system was developed consisting of a thermistor network and operational amplifiers to produce a linear analog temperature record, either on strip charts or magnetic tape.

SCHOLL, DAVID G., AND ALDEN R. HIBBERT.

1973.

Unsaturated flow properties used to predict outflow and evapotranspiration from a sloping lysimeter.
Water Resour. Res. 9:1645-1655.

Both moisture outflow and evapotranspiration from sloping soils can be predicted from moisture content, pressure potential, and rainfall by using Darcian and water-balance methods. Estimating these factors on watersheds is limited by sampling problems associated with natural heterogeneity.

SCHULTZ, ROBERT W.

1973.

Snowmelt lysimeters perform well in cold temperatures in central Colorado.
USDA For. Serv. Res. Note RM-247, 8 p.

Comparison between lysimeter and snow-tube measurements of melt rates indicated that the lysimeters provided reliable measurements of snowmelt. The lysimeter frame did not noticeably affect the thermal regime of the snow within the lysimeter.

SOMMERFELD, R. A., AND F. WOLFE, JR.

1972.

A centrifugal tensile tester for snow.
USDA For. Serv. Res. Note RM-227, 4 p.

A new centrifugal tensile tester has been designed for snow samples. The new design corrects many of the deficiencies of the older design.

STEPPUHN, H.,* J. R. MEIMAN,* AND B. C. GOODELL.

1972.

Automatic detection of water-borne fluorescent tracers.
Int. Assoc. Sci. Hydrol. Bull. 16(4):83-89.

A continuous, automatic, film system detects tracer concentrations of one part per billion, provides a time distribution of concentration changes, and combines low cost with ready portability. Field installations are self-operative for up to 10 days.

SWANSON, R. H.

1972.

Water transpired by trees is indicated by heat pulse velocity.
Agric. Meteorol. 10:277-281.

Daily total transpiration was linearly related to heat pulse velocities (HPV) measured once each day at noon or for periods centered at noon. Correlation coefficients were above 0.98. HPV was shown to be a function of transpiration and water movement into storage.

THOMPSON, J. R., AND A. D. OZMENT.

1972.

The Rocky Mountain millivolt integrator for use with solar radiation sensors.
USDA For. Serv. Res. Note RM-225, 8 p.

Electronic integration of a radiometer's millivolt signal is a practical and accurate means of obtaining hourly, daily, weekly, or long-term radiation values. Our integrator consists of four printed circuit boards, a synchronous bi-directional stepper motor, and 5-decade counter. Each integrator is calibrated to match the millivolt output of the radiation sensor, so that the counter reads directly in langleys. The totalizing of a signal from a typical net radiometer (with a 6.20mv/langley output) would be within plus or minus 1 percent over most of the positive signal range, but could be 5 percent too low at night when the sensor output is negative.

YAMAMOTO, TERUO.

1974.

Seismic refraction analysis of watershed mantle related to soil, geology and hydrology.
Water Resour. Bull. 10:531-546.

Isopachs, area-elevation curves, and structure contours were used together with drill cores, petrography, hydrographs, and soil information to interpret the nature and role of porous mantle in the waterflow behavior of small watersheds on a laccolith near Sturgis, South Dakota.

Multiple Use Relations

BAKER, MALCHUS B.,JR., AND HARRY E. BROWN.
1974.
Multiple use evaluations on ponderosa pine forest land.
p. 18-25. *In* 18th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1974] Proc. Ariz. Water Comm. Rep. 6, 60 p., Phoenix, Ariz.
Resume of USDA For. Serv. Res. Pap. RM-129, the status-of-our-knowledge publication by the Rocky Mountain Station. A copy of the Proceedings may be requested from the Arizona Water Commission, Phoenix.

BAKER, MALCHUS B., JR.
1975.
Modeling management of ponderosa pine forest resources.
Watershed Manage. Symp., ASCE Irrig. Drain. Div. [Logan, Utah, Aug. 1975] Proc. 1975:478-493.
Manipulating forests on volcanic soils in Arizona showed that: water-yield increases of 0.6 inch are realistic; harvestable timber growth can be increased, even with reduced basal area; understory plant growth and deer and elk habitat can be improved; economic returns can be increased, even when environmental factors are emphasized.

CARDER, D. ROSS.
1975.
Woods Canyon--a large scale watershed management experiment: An explanation and interim report.
p. 43-46. *In* 19th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1975] Proc. Ariz. Water Comm. Rep. 7, 51 p. Phoenix, Ariz.
Woods Canyon could become more a demonstration of methods for improving multiple-use planning and management than for improving water yields. Improved models will be used to predict yield changes after various treatment alternatives. Existing gaging stations and other field measurements will show accuracy of model predictions.

CLARY, WARREN P.
1974.
Pinyon-juniper control--does it pay?
p. 26-29. *In* 18th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1974] Proc. Ariz. Water Comm. Rep. 6, 60 p., Phoenix, Ariz.
Resume of USDA For. Serv. Res. Pap. RM-128, the status-of-our-knowledge publication by the Rocky Mountain Station. A copy of the Proceedings may be requested from the Arizona Water Commission, Phoenix.

CLARY, WARREN P.
1975.
Multiple use effects of manipulating pinyon-juniper.
Watershed Manage. Symp., ASCE Irrig. Drain. Div. [Logan, Utah, Aug. 1975] Proc. 1975:469-477.
Mechanical methods of pinyon-juniper removal are not likely to increase water-yields; herbicidal treatments may. Herbage yields increase after all treatments; deer response is generally neutral. The more successful conversion projects about break even financially.

DIETERICH, JOHN H.
1975.
Chaparral management: Its potential--its problems--its future.
p. 47-51. In 19th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1975] Proc. Ariz. Water Comm. Rep. 7, 51 p. Phoenix, Ariz.
Chaparral is now managed primarily by protection, rather than by design. Research indicates that more intensive management would modestly increase or improve wildlife habitat, water yield, grazing capacity, and wildfire control.

HIBBERT, ALDEN R.
1974.
Water resources research on forest and rangelands in Arizona.
p. 1-9. *In* Vol. 4, Hydrol. Water Resour. in Ariz. and the Southwest. Proc. 1974 Meet. Ariz. Sect., Am. Water Resour. Assoc. and Hydrol. Sect., Ariz. Acad. Sci., Flagstaff.
A two-pronged research effort is underway to provide a sound basis for managing water resources on Southwest forests and rangelands. In addition to its ongoing research program, the Rocky Mountain Station has joined with nine universities to form the Eisenhower Consortium to improve our understanding of the relationships between man and his environment.

HIBBERT, ALDEN R.
1974.
Chaparral research for water and other resources.
p. 30-36. *In* 18th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1974] Proc. Ariz. Water Comm. Rep. 6, 60 p., Phoenix, Ariz.
Resume of USDA For. Serv. Res. Pap. RM-126, the status-of-our-knowledge publication by the Rocky Mountain Station. A copy of the Proceedings may be requested from the Arizona Water Commission, Phoenix.

HIBBERT, ALDEN R., EDWIN A. DAVIS, AND THOMAS C. BROWN.
1975.
Managing chaparral for water and other resources in Arizona.
Watershed Manage. Symp., ASCE Irrig. Drain. Div. [Logan, Utah, Aug. 1975] Proc. 1975:445-468.
About 21 percent of the 3.5 million acres of chaparral in Arizona could be converted to grass to improve water and forage production. The expected annual increase of 150,000 acre-feet, however, would increase Arizona's total water supply only about 2 percent.

HORTON, JEROME S.
1972.
Management problems in phreatophyte and riparian zones.
J. Soil Water Conserv. 27:57-61.
After the invasion of the aggressive tamarisk along streams, rivers, and flood plains of the arid Southwest, removal of phreatophyte vegetation for water savings was felt to be paramount. Now recreational use, wildlife protection, honey production, erosion prevention, and preservation of esthetic values must all be considered for optimum management.

HORTON, JEROME S.
1974.
Management alternatives for the riparian and phreatophyte zones in Arizona.
p. 40-42. *In* 18th Annu. Ariz. Watershed Symp. [Phoenix, Ariz., Sept. 1974] Proc. Ariz. Water Comm. Rep. 6, 60 p., Phoenix, Ariz.
Resume of USDA For. Serv. Res. Pap. RM-117, the status-of-our-knowledge publication by the Rocky Mountain Station. A copy of the Proceedings may be requested from the Arizona Water Commission, Phoenix.

LEAF, CHARLES F., AND ROBERT R. ALEXANDER.
1975.
Simulating timber yields and hydrologic impacts resulting from timber harvest on subalpine watersheds.
USDA For. Serv. Res. Pap. RM-133, 20 p.
A dynamic simulation model determines the hydrologic changes resulting from timber harvesting, and corollary models simulate timber yields. Emphasis is placed on the 'planning unit' which is defined by environmental characteristics, including combinations of slope, aspect, elevation, and forest cover.

MYERS, CLIFFORD A., AND MEREDITH J. MORRIS.
1975.
Watershed management practices and habitat values

in coniferous forests.
p. 288-295. *In* Proc. Symp. Manage. For. Range Habitats for Nongame Birds [Tucson, Ariz., May 1975]. USDA For. Serv. Gen. Tech. Rep. WO-1, 343 p. Wash., D.C.

Application of watershed management practices in coniferous forests can produce thinned stands, cleared openings, and new plantations. Clearcutting patches to increase water yields has the greatest potential for changing nongame bird habitats. Changes in the vegetative cover will increase habitat diversity, which is frequently, but not always, beneficial to birds.

OTHER

*Private, State or Federal cooperator

BOSTER, RONALD S., AND WILLIAM E. MARTIN.*
1972.
The value of primary versus secondary data in interindustry analysis: A study in the economics of the economic models.
Ann. Reg. Sci. 6(2):35-44.

In a case study of two input-output models, one from primary data, one from secondary, neither statistical analysis nor projection comparisons showed the aggregative components of one to be better than the other. The model developed from secondary sources was quite adequate, and vastly less expensive.

CLEMA, JOE K.,* AND MICHAEL A. FOSBERG.
1974.
SENSNX--A general subroutine for the sensitivity analysis of simulation models.
Ann. Simul. Symp. [Tampa, Fla., Mar. 1974] Proc. 7:253-263.

SENSNX is a FORTRAN subroutine designed to evaluate the sensitivity of simulation models by two methods. The first method is based on the statistical error associated with the independent variables. The second is designed to determine the uncertainty of the fixed finite errors of the independent data.

KERBS, ROGER R.
1972.
Handy device for dispensing barbed wire.
J. Range Manage. 25:72-73.

The device is held vertically in the rear stake pocket of a pickup truck. It costs about $6 to construct, reduces the possibility of wire entanglements, and frees one man of a two-man crew to do other work.

KOVNER, J. L., AND S. A. PATIL.
1973.
On the moments of the doubly truncated bivariate normal population with application to ratio estimate.
J. Indian Soc. Agric. Stat. 25(2):131-140.

The first four moments are obtained. From these, the movement estimators are obtained by an iterative procedure. These in turn are used to estimate the mean square error of the ratio estimator. A numerical example from a biological population is presented.

MESSNER, HAROLD E., DONALD R. DIETZ, AND E. CHESTER GARRETT.
1973.
A modification of the slanting deer fence.
J. Range Manage. 26:233-235.

This slanting deer fence requires less mesh wire and shorter posts than the standard upright deer fence. The slanting fence blends well into forest and meadow backgrounds, and will withstand greater snow loads than existing slanting deer fences.

NICKERSON, MONA F., AND GLEN E. BRINK.
1974.
Publications from the Rocky Mountain Forest and Range Experiment Station, 1953-73.
USDA For. Serv. Gen. Tech. Rep. RM-6, 96 p.

Lists all publications, alphabetically by author, issued since the consolidation of the Southwestern and the Rocky Mountain Stations in 1953.

PATIL, S. A.,* J. L. KOVNER, AND D. C. PATEL.*
1974.
The distribution of the MLE of the uniform correlation coefficient in the multivariate normal population.
Ann. Inst. Stat. Math. 26:403-411.

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Application of research findings is part of the larger problem of information retrieval and use. Since the effort needed to do this job adequately is too great for individuals with full-time management responsibilities, a team of technical experts on the manager's staff is needed to serve as information processors.

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seeking better ways to manage natural resources on forest and range lands in the great plains, central rockies and southwest

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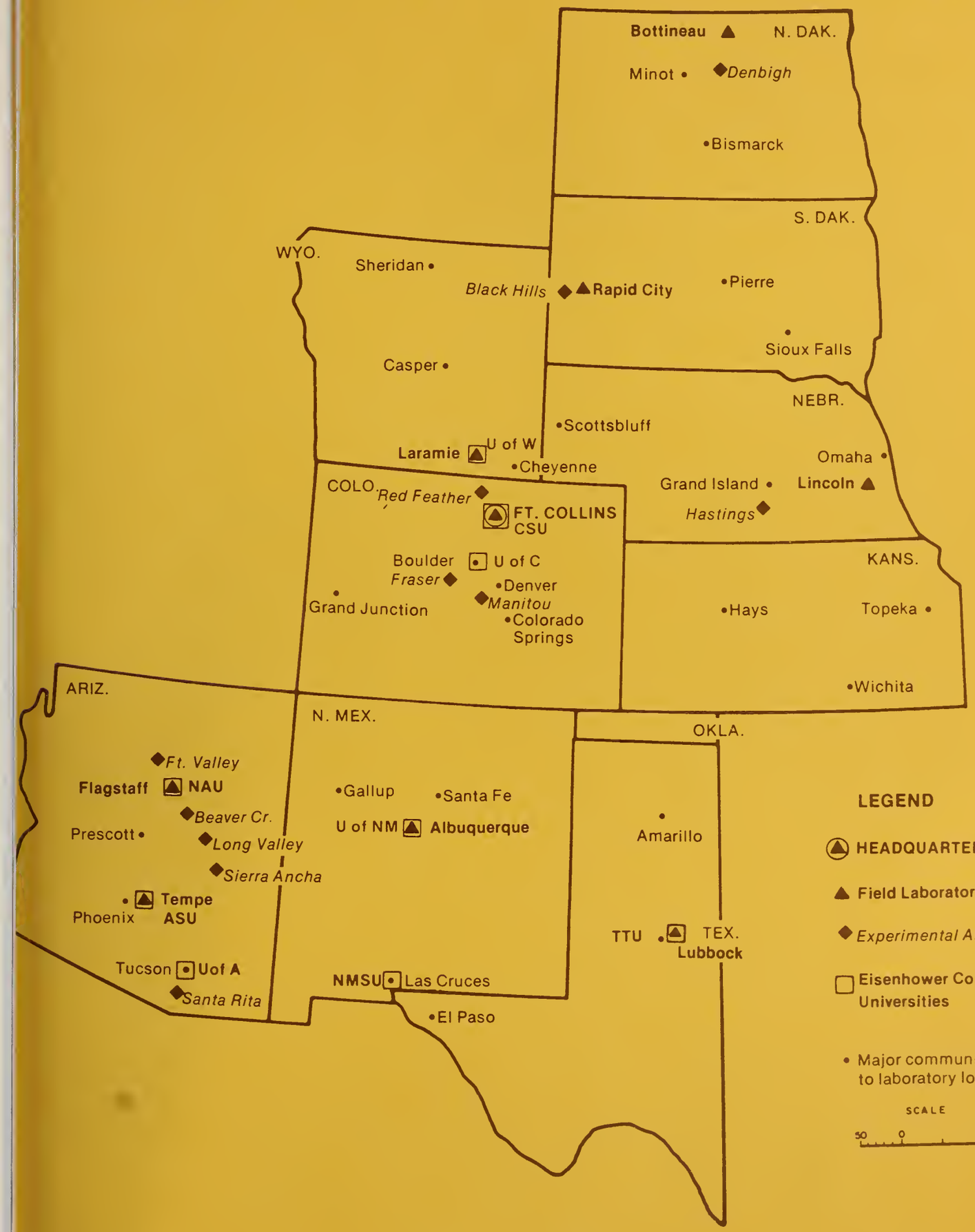

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- HEADQUARTERS
- Field Laboratories
- *Experimental Areas*
- Eisenhower Consortium Universities
- • Major communities in addition to laboratory locations

SCALE

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